# Travis County Drainage Basin Study — Volume 1

March 2009

HDR | ONE COMPANY *Many Solutions*®

# Travis County
# Drainage Basin Study
# Volume 1

***Prepared for:***

STATE OF TEXAS
CRISTOPHER L. PARKER
88602
LICENSED
PROFESSIONAL ENGINEER
3/19/09

STATE OF TEXAS
THOMAS F. CURRAN
61905
LICENSED
PROFESSIONAL ENGINEER
3/19/09

For Arroyo Doble and Twin Creek Park
Subdivision analysis only

***Prepared by:***

HDR | ONE COMPANY *Many Solutions*℠

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## *Executive Summary*

Travis County is located in an area well known as "flash flood alley" due to its vulnerability to flooding from intense storms combined with the steep terrain in western Travis County that feeds lower lying areas in the eastern part of the County. Flooding is the number one weather related cause of death in Texas.

Travis County maintains over 1,200 miles of roads in the unincorporated area serving an estimated 170,000 residents, with over 72 miles of roads located within the 100-year floodplain. There are many stream crossings in the County that are prone to frequent overtopping during storm events, posing a serious threat to public safety and the potential for loss of life. There are also a large number of homes and buildings within the 100-year floodplain. The County has undertaken efforts to identify these areas and systematically work toward mitigating many of these potential hazards. These efforts have included floodplain acquisition (buyouts) of the properties most at risk. In addition to these areas, there are numerous low water crossings and neighborhood (subdivision) areas with flooding problems for which the County needs to develop a plan for mitigation.

Travis County approved a total of $500,000 to perform a study to address flooding problems in the County. The County applied to the Texas Water Development Board (TWDB) for a Flood Protection Planning Grant in December 2006. The TWDB awarded the County a $195,000 grant in March 2007. The study was performed under the direction of the Travis County Transportation and Natural Resource Department (Road Maintenance Division). The County entered into an agreement with HDR Engineering, Inc. to perform the planning study and the study was initiated upon award of the grant.

The study area includes the watersheds of Big Sandy Creek, Cow Creek, Barton Creek, Slaughter Creek, Williamson Creek, Bee Creek, Onion Creek, Bull Creek, Dry Creek, Cottonwood Creek, Wilbarger Creek, Lockwood Creek, Gilleland Creek, Harris Branch, Walnut Creek, Decker Creek, Elm Creek, Cottonmouth Creek, South Fork, Dry East Creek, Maha Creek, Elm Creek South, and Cedar Creek. The planning area encompasses most of Travis County including the extra-terrestrial jurisdictions of various municipalities in the County including the City of Austin. All the watersheds in the planning area are located in the Colorado River Basin.

The primary goal of the study is to develop a plan to address the flood problems through an evaluation of problems on a watershed-wide basis to help guide Travis County in implementing measures to reduce the threat of flooding. The protection of public safety and welfare is the principal goal of the planning effort. This protection is the basic purpose for conducting the flood protection planning. Ultimately, problem areas deemed to be a severe threat to public safety and welfare due to poor drainage and flooding were given the highest priority with regard to development of solutions. This included the potential for loss of life, overtopping of well-traveled roadways, and flooding of homes and buildings.

It is important to note that various flood protection planning studies have been performed and are ongoing within the study area by Travis County, Lower Colorado River Authority, U.S. Army Corps of Engineers, City of Austin, and others. Some of these previous and ongoing studies overlapped portions of the study area. These studies have identified and quantified flooding issues in areas of Travis County, typically where a high concentration of residences exist that are subject to frequent flooding. There was a clear goal and objective for this study not to repeat previous work. This Drainage Basin Study should not be considered an all inclusive study for Travis County. Some areas of the County were excluded from the study area and this study also serves to supplement previous and ongoing studies. Many of the problems and solutions identified as part of this study were not a part of previous County planning efforts.

The study was performed by conducting the following tasks:

1. Data Collection and Surveying;
2. Hydrologic Analysis;
3. Hydraulic Analysis;
4. Flood Control Alternatives;
5. Economic Analysis;
6. Drainage Basin Study Report; and
7. Public Meetings.

Problem areas, as defined for this study, include specific areas of the County where frequent flooding poses a major threat to public safety and welfare and significant risk to property damage. Flood problem areas that were previously studied by others and those that are already being addressed with projects included in the County's 2005 Bond Program were excluded from this study. Preliminary problem areas were identified through interviews with County maintenance staff and input from Travis County citizens. Meetings were held with tenured Travis County maintenance personnel with abundant historical knowledge of flood problem areas throughout the County. Maintenance supervisors, engineers, and managers were interviewed from both the West and East service areas. Public input on flood problem areas was solicited through public meetings and through a website developed specifically for the study.

The goal of the public involvement effort was to identify other problem areas near where people live or work to supplement or validate the information obtained from County maintenance staff. Two public meetings were held at the beginning of the study, one at the West Service Center and one at the Satellite One Office, to solicit input from citizens in both the western and eastern portions of the County. The meetings were publicly advertised with public notices in community newspapers, notices to neighborhood associations, and strategically placed signs at major road intersections and other highly visible locations. During the meetings, an overview of the study goals and objectives was presented prior to opening the meetings up to one-on-one discussions with citizens about specific flood problem areas. In addition to the public meetings, a project web site was developed and maintained with the web site address of www.traviscountydrainage.com. The project web site was advertised as part of the public meeting advertisements and was utilized to convey study information and solicit input on the study.

Almost 100 preliminary problem areas were identified from the interviews with County staff and the public involvement effort. The problem areas were widely scattered throughout the County. Two primary types of problem areas emerged from the preliminary identification process; flood overtopping at stream crossings that impact emergency access and the ability of citizens to reach their homes during storm events, and flooding in more densely developed and particularly older residential (subdivision) areas. Data was collected at each of the problem areas including field survey, digital GIS data, and record information. Criterion was developed in consultation with County staff as a basis for screening and ranking the preliminary problem areas and develop a list of priority areas for additional study and alternatives analysis. Criteria included threat to public safety, impact to emergency access, flooding of habitable structures, and severity of the flood condition. Engineering analyses, including hydrologic and hydraulic modeling, were performed to provide additional information for each problem area and a final ranking was performed to narrow down the list to 40 priority problems areas for which mitigation alternatives were developed.

The final ranking of the 40 priority problem areas included additional criteria incorporating the results of the engineering analyses and additional public input. At the mid-point of the study, two additional public meetings were held, again at the West and East facilities. The final ranking of the 40 priority problem areas included six neighborhood (subdivision) areas with a concentration of flood prone residences and a number of roadway stream crossings where overtopping was found to be significant and frequent. Many of the high priority stream crossings serve as the single point of access to a large number of residences in the rural areas of the County. Due to the fact that driving into water is the number one weather-related cause of death in Central Texas, these roadway stream crossings were deemed to be points of significant threat to public safety and welfare.

Alternative analyses were performed for each of the 40 priority problem areas and mitigation plans were developed. Typically, one alternative mitigation plan was developed to meet the full drainage criteria currently enforced for new development and a second alternative plan was prepared to retrofit the problem area with improved drainage. The second alternative plan would not meet the full drainage criteria required for new development, but would provide significant improvement above and beyond existing conditions. Mitigation alternatives included non-structural alternatives of purchase of flood prone property and structural solutions included bridge and culvert upgrades, channel modifications, and storm drain system improvements. Capital cost estimates were prepared for each alternative for the 40 priority problem areas. Table ES-1 presents a summary of the estimated capital cost for the roadway stream crossings identified as needing improvement in the County. Table ES-2 presents a summary of the estimated capital cost for the flood prone neighborhood (subdivision) areas identified. Overall, the total capital cost estimate for the 40 priority problem areas range from approximately $22,600,000 for retrofits to provide improved drainage conditions to almost $50,000,000 to provide mitigation to a level meeting current full drainage criteria.

The recommended improvements will require several years to implement. The County could implement several of the recommended alternative plans using the County's own staff and equipment resources to construct the structural upgrades. However, for most of the recommended alternatives, the required improvements will likely need to be contracted to private companies. Funding for the recommended improvements may be derived from the County's normal annual operating budget. However, due to the magnitude of the capital costs involved, implementation will likely require funding from capital improvement bonds that would be issued in future years and potential assistance from the state and federal government.

## *Table ES-1.*
## *Summary of Estimated Capital Costs for Stream Crossings*

| *Final Rank* | *Problem Area* | *Crossing ID* | *Alternative 1- Minimum Design Capital Cost* | *Alternative 2- Full Design Criteria Capital Cost* |
|---|---|---|---|---|
| 1 | Big Sandy Dr @ Long Hollow Creek | LKT-005 | $319,150 | $711,274 |
| 2 | Springdale Road @ Walnut Creek | WLN-001 | $3,246,061 | $3,580,756 |
| 3 | Juniper Trail @ Long Hollow | LKT-004 | $416,672 | $1,186,676 |
| 4 | Wyldwood Road @ Slaughter Creek | SLA-004 | $549,105 | $1,528,560 |
| 5 | Great Divide Road @ Little Barton Creek | LBA-001 | $331,004 | $1,391,004 |
| 6 | Fall Creek Road @ Fall Creek | FAL-001 | $213,322 | $858,434 |
| 7 | Pedernales Canyon Trail @ Lick Creek | LCK-001 | $433,516 | $526,096 |
| 8 | Slaughter Creek Drive @ Trib 1 to Slaughter Creek | SLA-005 | $330,664 | $763,927 |
| 9 | Tumbleweed Trail @ unnamed trib to Lake Austin | LKA-001 | $59,999 | $154,205 |
| 10 | Crystal Bend Drive @ Harris Branch | HRS-001 | $274,730 | $1,381,232 |
| 11 | Cottonwood Drive @ Long Hollow | LKT-003 | $224,372 | $867,244 |
| 12 | Jacobson Road @ Maha Creek | MAH-008 | $201,247 | $458,937 |
| 13 | Linden Road @ Maha Creek | MAH-009 | $404,168 | $3,576,385 |
| 14 | Live Oak Drive @ Sheep Hollow | LKT-002 | $168,329 | $339,730 |
| 15 | Springdale Road @ Trib 5 to Walnut Creek | WLN-002 | $183,741 | $270,946 |
| 16 | Gregg Lane @ Wilbarger Creek | WLB-004 | $278,039 | $1,371,626 |
| 17 | Jesse Bohls Rd. @ unnamed trib to Wilbarger Creek | WLB-002 | $279,310 | $2,189,503 |
| 18 | Lime Creek Road @ Fisher Hollow | LKT-010 | $165,130 | $557,420 |
| 19 | Nameless Road @ unnamed trib to Big Sandy | LKT-001 | $284,248 | $918,510 |
| 20 | D Morgan Road @ Trib to Grape Creek | BAR-002 | $96,854 | $683,118 |
| 21 | Bee Creek Road @ Bee Creek | WBC-001 | $379,595 | $924,162 |
| 22 | Navarro Creek Rd @ Navarro Creek | DRE-006 | $211,053 | $1,343,902 |
| 23 | Bitting School Road @ unnamed trib to Wilbarger Creek | WLB-012 | $655,131 | $5,276,098 |
| 24 | Weir Loop Circle @ Devil's Pen Creek | SLA-006 | $124,305 | $261,901 |
| 25 | Tom Sassman Road @ Maha Creek | MAH-003 | $1,123,764 | $1,726,228 |
| 26 | Felder Lane @ Cottonwood Creek | CTW-003 | $209,810 | $949,937 |
| 27 | Parsons Road @ Wilbarger Creek | WLB-009 | $437,766 | $1,584,547 |
| 28 | Westlake Drive @ unnamed trib to Lake Austin | WDT-001 | $46,452 | $131,656 |
| 29 | Nameless Road @ Nameless Hollow | LKT-007 | $220,924 | $1,257,092 |
| 30 | Ledgestone Terrace @ unnamed trib to Pen Creek | SLA-007 | $125,457 | $125,457 |
| 31 | Wild Basin Street @ unnamed trib to Bee Creek | BEE-001 | $81,451 | $146,876 |
| 32 | Caldwell Ln @ River Timber Dr | COL-001 | $69,644 | $69,644 |
| 33 | Nameless Road @ unnamed trib to Big Sandy | LKT-006 | $181,569 | $400,979 |
| 34 | Weir Loop @ Williamson Creek | WMS-001 | $47,209 | $58,075 |
| | | **Grand Total** | **$11,989,240** | **$36,815,718** |

**Table ES-2.**
**Summary of Estimated Capital Costs for Subdivision Areas**

| Final Rank | Problem Area | Alternative 1 Capital Cost | Alternative 2 Capital Cost |
|---|---|---|---|
| 1 | Swiss Alpine Subdivision | $947,835.16 | $2,069,741.75 |
| 2 | Arroyo Doble Subdivision | $1,049,473.00 | $1,243,873.00 |
| 3 | Twin Creeks Park Subdivision | $344,550.00 | $538,242.00 |
| 4 | Thoroughbred Farms Subdivision | $700,663.82 | $997,334.86 |
| 5 | Southwest Territory Subdivision | $916,439.83 | $1,071,206.64 |
| 6 | Austin Lake Estates Subdivision | $2,353,985.38 | $2,997,881.68 |
| | Subtotal Structural Improvements | $6,312,947 | $8,918,280 |
| | | | |
| | Swiss Alpine Subdivision Acquisitions | $3,740,915 | $3,902,147 |
| | **Grand Total** | **$10,053,862** | **$12,820,427** |

# Section 1
# Introduction

## 1.1 Background

Travis County is located in south-Central Texas (Figure 1-1) and is home to over 960,000 people. The Austin-Travis County metro area is one of the fastest growing areas in Texas and the U.S. From 1990 to 2000, the population of the metro area grew by 41% to over 812,000 people. Most of the population is located within the incorporated area of the City of Austin, as well as other smaller incorporated areas within Travis County. The population of the unincorporated areas (Figure 1-2) is estimated to be about 166,000 with a density of about 820 persons per square mile. Development within the unincorporated area of Travis County continues at a rapid pace.

***Figure 1-1. Study Area Location***

Travis County has a long history of flooding. The County, like most areas within Texas receives much of its annual rainfall in a few large storms. Storms are produced in the spring from cool, dry air moving in from the northern region of the U.S. colliding with warm moist air from the Gulf of Mexico. The resulting thunderstorms in the south central Texas area have created some of the most extreme rainfall rates ever recorded in the world. Hurricanes and Tropical Storms originating in the Gulf of Mexico and Carribean Sea will also push inward into Texas, often times stalling and expending themselves over central Texas, producing extremely heavy rainfall.[1]

Travis County is particularly vulnerable to flash flooding. The western half of the County is defined as the Hill Country area and runoff generally flows southeast to the lower lying areas in the eastern part of the County. The Hill Country area is well known as "flash flood alley" as it is very prone to flooding due to its steep terrain and thin soils. When the intense storms are combined with this terrain, it produces some of the highest runoff rates in the United States.

[1] Votteler, Todd H., Ph.D., "Flood", Guadalupe-Blanco River Authority,

Flooding is the number one weather-related cause of death in Texas. Most recently, Texas leads the nation in the most flood/flash flood deaths with total deaths double the second-highest state, California.[2] Driving into water is the primary cause of weather-related deaths in Central Texas. Because thunderstorms typically form in the most intense heat of the day, the resulting flash floods often occur in the evening hours when it is dark and difficult for drivers to see the impending danger clearly. Therefore, many times drivers are unaware that they are entering a hazardous situation until it is too late.


Austin American-Statesman
Storms across Texas: Pages A8-10
5 perish as rains rage
Hundreds crowd shelters; rescue crews brace for more

Travis County maintains over 1,200 miles of roads in the unincorporated area, with over 72 miles of roads within the 100-year floodplain. There are many stream crossings in the County that are prone to frequent overtopping during storm events, posing a serious threat to public safety and the potential for loss of life. The County also has a large number of homes and buildings within the 100-year floodplain. Current estimates are that there are about 6,800 buildings in the floodplain in the unincorporated areas of the County, located within almost every major watershed[3]. However, there are specific areas where concentrations of residences exist. The County has undertaken efforts to identify these areas and systematically work toward mitigating many of these potential hazards. These efforts have included floodplain acquisition (buyouts) of the properties most at risk. In addition to these areas, there are numerous low water crossings and neighborhood (subdivision) areas with flooding problems that the County needs to develop a plan for mitigation.


Travis County, in cooperation with other local political subdivisions, applied to the Texas Water Development Board for a Flood Protection Planning Grant in December 2006. The Texas Water Development Board awarded the County a $195,000 grant in March 2007, that matched the County's $465,000 contribution, to provide a total of $660,000 to perform a planning study

[2] Flood Damage and Fatality Statistics, Flood Safety, Web Site, www.floodsafety.com, 2008.
[3] Hazard Mitigation Plan, Travis County, Texas, June 2003.

to address flooding problems in the study area. The study was performed under the direction of the Travis County Transportation and Natural Resource Department (Road Maintenance Division). The County entered into an agreement with HDR Engineering, Inc. to perform the planning study and the study was initiated upon award of the grant.

### *1.2 Study Area*

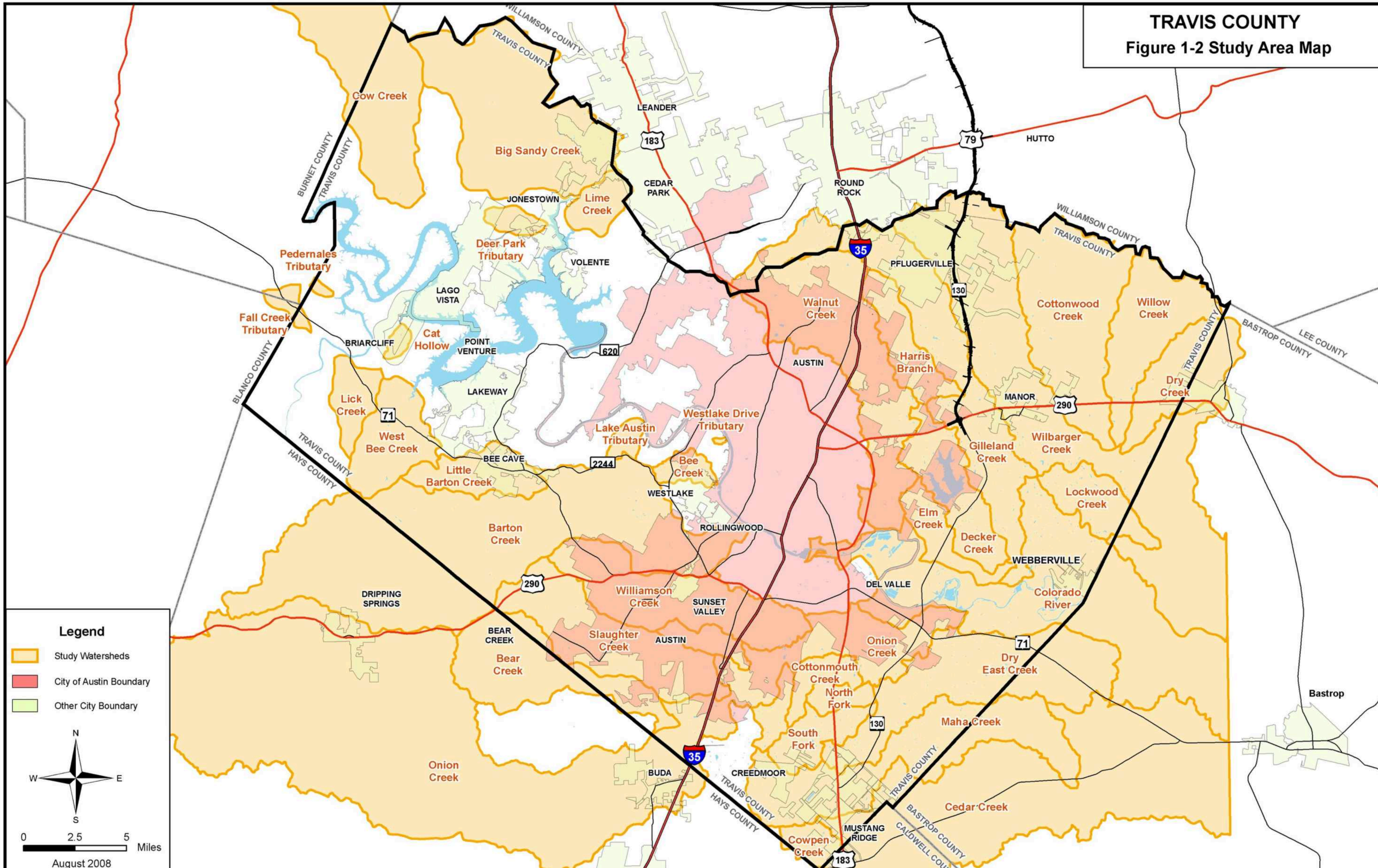
The study area includes the watersheds of Big Sandy Creek, Cow Creek, Barton Creek, Slaughter Creek, Williamson Creek, Bee Creek, Onion Creek, Bull Creek, Dry Creek, Cottonwood Creek, Wilbarger Creek, Lockwood Creek, Gilleland Creek, Harris Branch, Walnut Creek, Decker Creek, Elm Creek, Cottonmouth Creek, South Fork, Dry East Creek, Maha Creek, Elm Creek South, and Cedar Creek. The planning area encompasses most of Travis County including the extra-territorial jurisdictions of various municipalities in the County including the City of Austin. All the watersheds in the planning area are located in the Colorado River Basin. Figure 1-2 shows a map of the study area.

### *1.3 Goals and Objectives*

The primary goal of the study is to develop a plan to address the flood problems through an evaluation of problems on a watershed-wide basis to help guide Travis County in implementing measures to reduce the threat of flooding. The protection of public safety and welfare is the principal goal of the planning effort. This protection is the basic purpose for conducting the flood protection planning. Ultimately, problem areas deemed to be a severe threat to public safety and welfare due to drainage and flooding were given the highest priority with regard to development of solutions. This included the potential for loss of life, overtopping of well-traveled roadways, and flooding of homes and buildings.

It is important to note that various flood protection planning studies have been performed and are ongoing in the study area by Travis County, Lower Colorado River Authority, U.S. Army Corps of Engineers, City of Austin, and others. Some of these previous and ongoing studies overlapped portions of the study area. These studies have identified and quantified flooding issues in areas of Travis County, typically where a high concentration of residences exist that are subject to frequent flooding. There was a clear goal and objective for this study not to repeat previous work. This Drainage Basin Study should not be considered an all

# TRAVIS COUNTY
## Figure 1-2 Study Area Map




R:\100534_Travis_County_TX\100534-58492_Travis_Co_Drainage_Basin_Study\GIS\map_docs\arcmap\travis_county_study_wsheds_062607.mxd inclusive study for Travis County as some areas of the County were excluded from the study area. Many of the problems and solutions identified as part of this study were not a part of previous County planning efforts.

The study was performed by conducting the following tasks:

1. Data Collection and Surveying;
2. Hydrologic Analysis;
3. Hydraulic Analysis;
4. Flood Control Alternatives;
5. Economic Analysis;
6. Drainage Basin Study Report; and
7. Public Meetings.

The data collection task of the study included compiling existing information from a variety of sources including the Federal Emergency Management Agency (FEMA), Travis County (County), Texas Natural Resources Information System (TNRIS), City of Austin, and other sources. Field investigations were performed for identified drainage and flood problem areas and ground surveying was performed for specific problems areas to obtain data on creeks, channels, bridges, culverts, and other drainage features.

The hydrologic analysis task included delineation of watershed boundaries for major and minor watersheds, computation of watershed parameters, development of rainfall-runoff models, and computation of peak runoff rates at selected locations.

The hydraulic analysis task included development of stream hydraulic models for identified high priority flood problem areas. Some of the streams in the unincorporated areas have been hydraulically modeled as part of the recent FEMA Travis County Floodplain Mapping Study. These models were utilized where appropriate as part of the study.

The task of development of flood control alternatives included evaluation of both structural and non-structural solutions. High priority problem areas were identified in the early stages of the study through interviews with County Maintenance staff on areas of known frequent flooding, from frequent Emergency Response Team call-ins and/or public complaints, and from the public involvement process and the numerous public meetings held during the planning study. Based on the identified high priority problem areas, alternatives focused primarily on structural solutions as non-structural solutions were not practical in most cases.

Bridge, culvert, roadway, and channel improvements were evaluated to mitigate for the flood-related problems identified during the course of the study. Conceptual designs for multiple alternatives were prepared for 40 different problem areas.

Economic analyses were performed for each problem area. The economic analyses generally included preparation of capital cost estimates for each improvement plan. The economic analysis task also included prioritizing each proposed improvement project and evaluation of potential financing and funding options for implementation of the plan.

The draft report was prepared at the conclusion of the study to document the study results, data, methods, and assumptions used. The draft report was distributed to the County and the Texas Water Development Board for review and comment and was made available to the general public.

Public meetings were held during the course of the study to solicit input from the general public for the planning effort. Two meetings were held near the beginning of the study to describe the goals and objectives of the study and solicit input on existing drainage problems in the study area. In order to provide geographic diversity for the public meetings, the first meeting was held in western Travis County at the County's West Service Center and a second meeting was held in eastern Travis County at the County's Satellite One office. At the mid-point of the study, a public briefing was made to the Travis County Commissioners Court and two additional public meetings were held, again at the West and East facilities. In addition to the public meetings, a project web site was developed and maintained with the web site address of www.traviscountydrainage.com The project web site was advertised as part of the public meeting advertisements and was utilized to convey study information and solicit input on the study. The draft report for the study was published on the web site for public review and comment.

### *1.4 Previous Study Efforts*

There have been numerous study efforts from a variety of public agencies for Travis County. These studies include the Travis County Map Modernization Program that was initiated in October 2003.[4] The ensuing technical data was released for public comment in 2006 and

[4] Halff Associates, Travis County Map Modernization Program, http://www.halff-femastudy.com, August 2008.

again in 2007. The Federal Emergency Management Agency (FEMA) initiated and managed the mapping project in association with the City of Austin, Travis County, eleven other Travis County communities, the Lower Colorado River Authority, the U.S. Army Corps of Engineers, and the State of Texas. The Travis County Map Modernization project included the development of GIS-based hydrologic and hydraulic models and floodplain maps of many watersheds in Travis County. Because of its susceptibility to flash flooding and its rapid growth, Travis County was one of the first counties in the nation chosen by FEMA for participation in its Map Modernization Program. The program includes the development of digital flood insurance rate maps. Digital Flood Insurance Rate Maps (DFIRMs) will replace the current (paper) Flood Insurance Rate Maps and include database information related to the underlying base maps and technical floodplain data. The newly developed DFIRMS for Travis County will become effective on September 26, 2008. All or portions of the following watersheds within the unincorporated area of Travis county were included in the detailed study effort: Colorado River including Lake Travis; Walnut Creek; Onion Creek; Johnson Creek; Dry North Creek; and Harris Branch.

Travis County also developed a Hazard Mitigation Plan (HMP) which was formally adopted in 2003.[5] The HMP is a comprehensive overview of potential hazards that threaten the County and characterizes the people and property that are exposed to some risk as a result of these potential hazards. The County undertook the effort due to an increase in the awareness in how natural and manmade disasters, especially flood hazards, impact many people and property in the County. The HMP identified priority mitigation action items with the four highest priority action items including:

1. Development of a communications plan to improve interactions with the public, both before and after floods.
2. Explore expansion of the City of Austin's flood warning system to increase citizen safety.
3. Integrate property parcel maps with the tax database to improve permit administration and support public outreach efforts.
4. Continue efforts to identify and implement mitigation options in high-risk areas to reduce future losses.

[5] Hazard Mitigation Plan, Travis County, Texas, June 2003.

The development of the HMP also fulfilled a requirement associated with the County's ability to obtain funds as part of federal mitigation grant programs administered by the Texas Division of Emergency Management and the Texas Water Development Board.

The U.S. Army Corps of Engineers (USACE), in cooperation with local sponsors including Travis County, Lower Colorado River Authority, City of Austin, and others performed flood studies of the Lower Colorado River Basin that include portions of the unincorporated areas of Travis County.[6] This study identified flooding problems in the Onion Creek Watershed for specific stream reaches including the Timber Creek area, Bear Creek/Onion Creek confluence (Arroyo Doble) area, and Bluff Springs Road area. Flood mitigation plans were developed for these areas and the plans for Timber Creek and Arroyo Doble are being implemented and funded jointly, and in some cases, in cooperation with the federal government. The County included funding in the 2005 Bond Program for acquisition of four homes in the Arroyo Doble area and all remaining properties located in the 25-year floodplain for the Timber Creek area, as recommended by the USACE study. The County also identified a collection of 12 homes in the Thoroughbred Farms Subdivision, located along the South Fork of Dry Creek, as having suffered repeated flood damage. These homes were also included in the 2005 Bond Program for acquisition. Several homes along Walnut Creek, in a neighborhood downstream of the City of Austin, were previously found to be flood prone and threatened by severe erosion. Investigations and engineering studies were completed by the County and 6 homes along Quiette Drive and Chimney Hill Blvd, which were most threatened by erosion, were included for acquisition as part of the 2005 Bond Program. Furthermore, the U.S. Army Corps of Engineers along with the Lower Colorado River Authority and local sponsors are currently performing a comprehensive study of the Walnut Creek watershed (Walnut Creek Interim Feasibility Study) with results expected to be published in 2009. The

**Flood Damage in Timber Creek, November 2001**

**Flood Damage in Graveyard Point, December 1991**

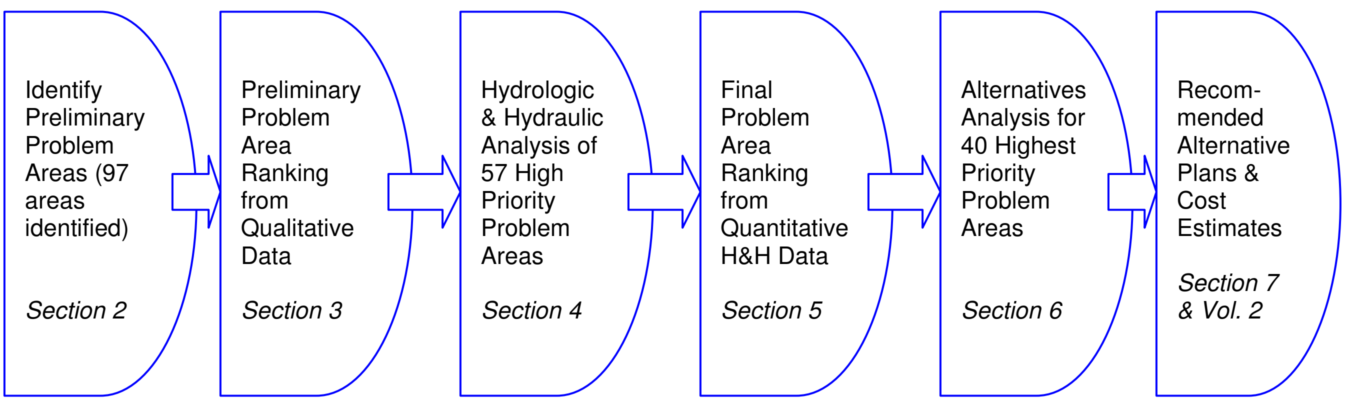
[6] U.S. Army Corps of Engineers, Fort Worth District, Lower Colorado River Basin Phase I, Texas, Interim Feasibility Report and Integrated Environmental Assessment, October 2006.

County is also evaluating the potential for acquisition of flood prone structures in the Graveyard Point area along Lake Travis. Many of the homes in Graveyard Point have incurred flood damages on a relatively frequent basis. The County has applied for a hazard mitigation grant from FEMA for potential acquisition of 30 properties in the Graveyard Point area and the County is evaluating other options in cooperation with the USACE to mitigate the flooding in this area.

### *1.5 Organization of Planning Documents*

The flood protection planning study report is divided into two volumes. Volume 1 includes background data and a description of the methodology and analyses performed. Volume 2 includes a summary of the recommended solutions, alternatives, and cost estimates for the high priority problem areas identified as part of the study. A CD-ROM is also incorporated into the submittal which includes electronic data including computer model and GIS data produced as part of the study effort.

The flowchart below represents the basic Flood Protection Planning Study approach and defines the report section that describes each step in the process.




This planning report includes 8 sections. Section 1 provides an introduction, study goals and objectives, and other background information. Section 2 provides a description of how flood problem areas were initially identified including the methodology employed and results. A Public Input Log was developed as part of this process and is included in Appendix A. Section 3 describes the methodology employed for preliminary ranking of the identified flood problems areas. Section 4 describes the hydrologic and hydraulic analyses and the methods used to compute peak runoff rates and model the hydraulics associated with the preliminary high priority problem areas. Appendix B includes the hydrologic input information and results, drainage area maps, soils maps, and maps of existing flooding for each problem area studied. Section 5 presents the final problem area prioritization and evaluation criteria utilized based on the hydrologic and hydraulic analyses. Section 6 presents the background and methodologies of the flood mitigation alternative analyses. Section 7 presents a summary of the recommendations from the study effort. Conceptual alternative design plans and capital cost estimates are presented in Volume 2. Section 8 describes potential funding alternatives and implementation of the study recommendations.

Appendix C includes the hydrologic and hydraulic analysis and assessment of the Pamela Heights and King's Village subdivision areas prepared separately by CAS Consulting & Services, Inc.

# Section 2
# Problem Area Identification

Problem areas, as defined for this study, include specific areas of the County where frequent flooding poses a major threat to public safety and welfare and significant risk to property damage. Flood problem areas that were previously studied by others as described in Section 1 and those that are already being addressed with projects included in the County's 2005 Bond Program were excluded from this study. Preliminary problem areas were identified through two primary means; interviews with County maintenance staff, and input from Travis County citizens.

## 2.1 Information from Travis County Staff

Meetings were held with tenured Travis County maintenance personnel with abundant historical knowledge of flood problem areas throughout the County. Maintenance supervisors, engineers, and managers were interviewed from both the West and East service areas. Areas known to have a history of frequent property flooding, road closures, and public complaints were discussed. During these interviews, problem areas were delineated on customized County road maps and lists of preliminary problem areas were developed.

## 2.2 Public Input

Public input on flood problem areas was solicited through public meetings and through a website developed specifically for the study. The goal of the public involvement effort was to identify other problem areas near where people live or work to supplement or validate the information obtained from County maintenance staff.

### 2.2.1 Public Meetings


Two public meetings were held at the beginning of the study, one at the West Service Center and one at the Satellite One Office, to solicit input from citizens in both the western and eastern portions of the County. The meetings were publicly advertised with public notices in community newspapers, notices to neighborhood associations, and strategically placed


signs at major road intersections and other highly visible locations. During the meetings, an overview of the study goals and objectives was presented prior to opening the meetings up to one-on-one discussions with individual citizens about specific flood problem areas. Detailed maps of the County including aerial photos and topography were provided at the meeting to aid in the discussions. Citizen Input Forms were also provided at the meetings to allow citizens to provide input on flood problem areas in written form for their convenience.

### *2.2.2 Project Website*

A website was developed to provide information to the public about the study and to provide a convenient way for the public to submit information on observed or known flood problem areas (Figure 2-1). The project website included an electronic Flood Observation Questionnaire form for citizens to complete (Figure 2-2). Digital photos could also be attached with the electronic form. The forms were then emailed directly to HDR for review and logging. An email address was also provided on the website for citizens to submit flood problem data directly via email. A log of citizen input received is included as *Appendix A*. The project website also included an overview of the study and summaries of each study phase, as well as a map of the study area, and digital photos of recent flooding events.

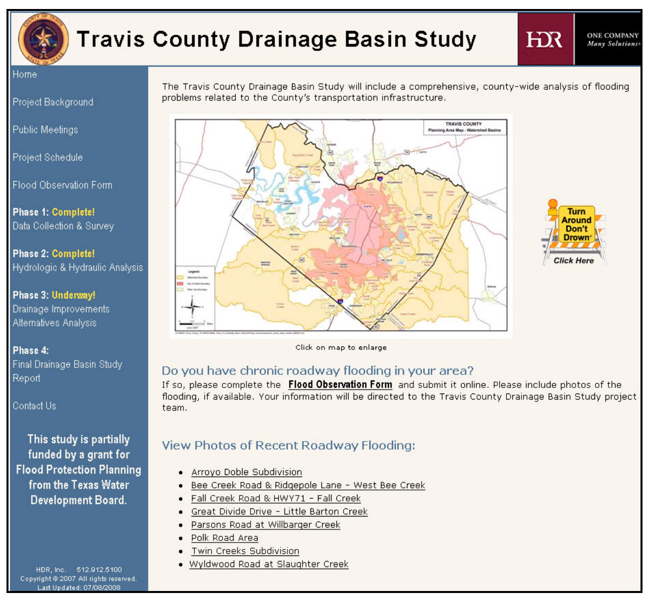
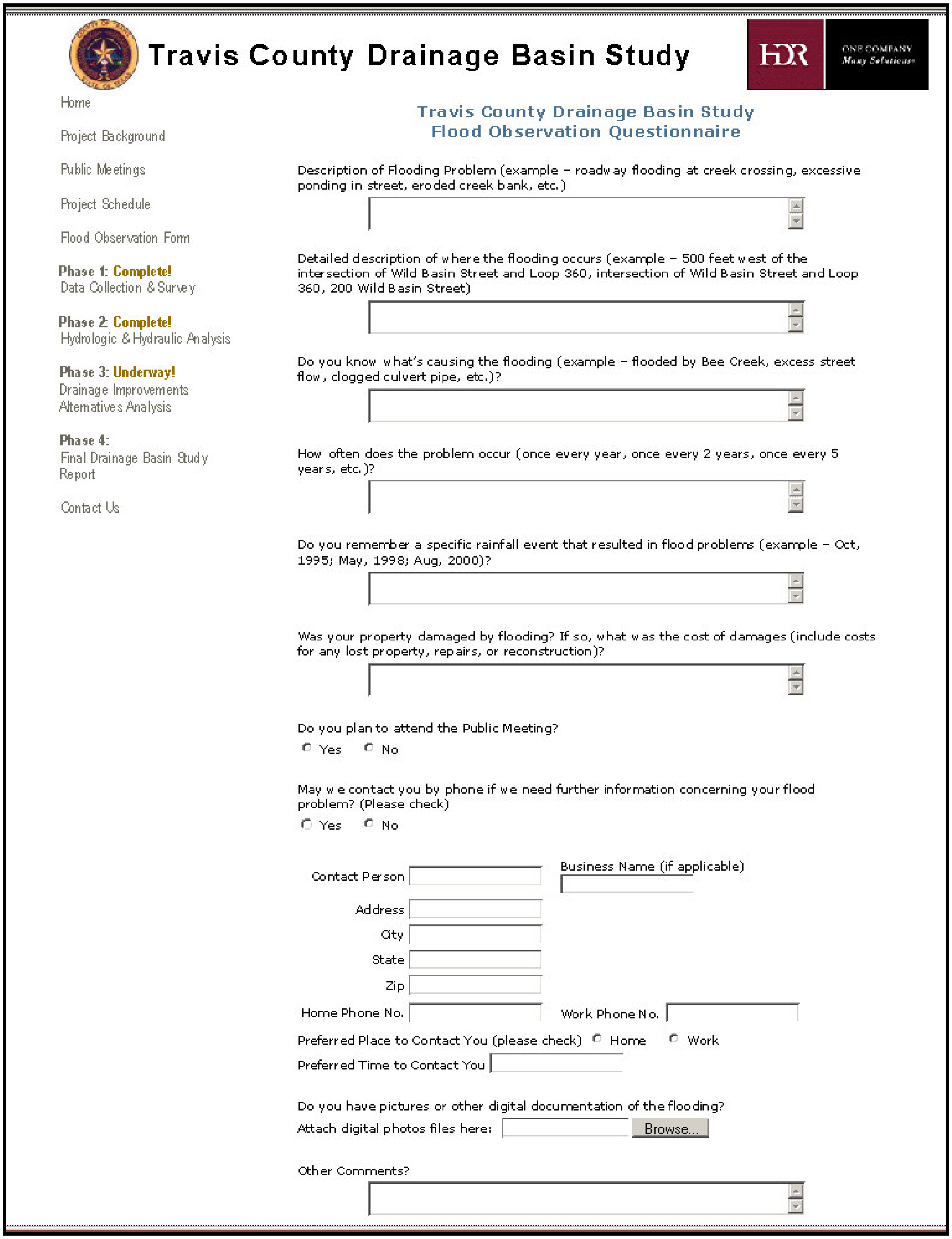



***Figure 2-1. Travis County Drainage Basin Study Website***



Travis County Drainage Basin Study

Home

Project Background

Public Meetings

Project Schedule

Flood Observation Form

Phase 1: Complete!
Data Collection & Survey

Phase 2: Complete!
Hydrologic & Hydraulic Analysis

Phase 3: Underway!
Drainage Improvements Alternatives Analysis

Phase 4:
Final Drainage Basin Study Report

Contact Us

Travis County Drainage Basin Study
Flood Observation Questionnaire

Description of Flooding Problem (example – roadway flooding at creek crossing, excessive ponding in street, eroded creek bank, etc.)

Detailed description of where the flooding occurs (example – 500 feet west of the intersection of Wild Basin Street and Loop 360, intersection of Wild Basin Street and Loop 360, 200 Wild Basin Street)

Do you know what's causing the flooding (example – flooded by Bee Creek, excess street flow, clogged culvert pipe, etc.)?

How often does the problem occur (once every year, once every 2 years, once every 5 years, etc.)?

Do you remember a specific rainfall event that resulted in flood problems (example – Oct, 1995; May, 1998; Aug, 2000)?

Was your property damaged by flooding? If so, what was the cost of damages (include costs for any lost property, repairs, or reconstruction)?

Do you plan to attend the Public Meeting?
Yes No

May we contact you by phone if we need further information concerning your flood problem? (Please check)
Yes No

Contact Person
Business Name (if applicable)
Address
City
State
Zip
Home Phone No.
Work Phone No.
Preferred Place to Contact You (please check) Home Work
Preferred Time to Contact You

Do you have pictures or other digital documentation of the flooding?
Attach digital photos files here: Browse...

Other Comments?

***Figure 2-2. Example Flood Observation Questionnaire***

### 2.2.3 Preliminary Problem Areas Identified

A total of 97 preliminary problem areas were identified from the interviews with County staff and public involvement effort. A list of the preliminary problem areas is provided in Table 2-1 and a map showing the problem area locations are shown on Figure 2-3. The problem areas were widely scattered throughout the County. Two primary types of problem areas emerged from the preliminary identification process; flood overtopping at county-road stream crossings (including low water crossings), and flooding in more densely developed and particularly older residential (subdivision) areas. Both types of problem areas involve runoff from both minor and major watersheds.

**Table 2-1.**
**Preliminary Identified Problem Areas**

| ***East Travis County*** | | ***West Travis County*** | |
|---|---|---|---|
| | ***Dry Creek Watershed*** | | ***Big Sandy Creek Watershed*** |
| DRY-001 | Lund Carlson Road @ Trib to Dry Creek | LKT-004 | Juniper Trail @ Long Hollow |
| DRY-002 | Klaus Lane @ Hwy 290 @ Trib to Dry Creek | LKT-002 | Live Oak Drive @ Sheep Hollow |
| DRY-003 | Albert Voelker Road @ Dry Creek | LKT-008 | Nameless Road @ Big Sandy near Linderman Lane |
| DRY-004 | Littig Road @ Dry Creek | LKT-006 | Nameless Road @ trib to Big Sandy Creek |
| | | LKT-013 | Round Mountain Dr @ Big Sandy Creek |
| | ***Cottonwood Creek Watershed*** | LKT-001 | Nameless Road north of Honeycomb Drive |
| CTW-004 | Cameron Road east of Cele Road | LKT-007 | Nameless Road @ Nameless Hollow |
| CTW-001 | Cameron Road north of Hamann Lane | LKT-003 | Cottonwood Drive @ Long Hollow |
| CTW-002 | Cameron Road sourth of Hamann Lane | LKT-005 | Big Sandy Drive @ Long Hollow |
| CTW-003 | Felder Lane @ Cottonwood Creek | | Cross Creek Subdivision |
| CTW-005 | Brita Olson Road west of Axell Lane | | |
| CTW-007 | Brita Olson Road east of Axell Lane | | ***Lime Creek Watershed*** |
| WLW-001 | Sandeen Road @ Manda Carlson Road | | *Low Water Crossings* |
| | Bois D'Arc Road @ Trib to Cottonwood Creek | LKT-010 | Lime-Creek Road @ Lime Creek |
| | | | Trails End Subdivision |
| | ***Willbarger Creek Watershed*** | LKT-009 | Wire Road area |
| WLB-001 | Jesse Bohls Road west Trib | | |
| WLB-002 | Jesse Bohls Road east Trib | | ***Reed Park Trib Watershed*** |
| WLB-003 | Cameron Road @ Willbarger Creek | LKT-011 | Reed Park Road @ Trib to Lake Travis |
| WLB-005 | Gregg Lane @ Trib to Willbarger Creek | | |
| WLB-004 | Gregg Lane @ Willbarger Creek | | ***Cow Creek Watershed*** |
| WLB-007 | Rector Loop near Gregg Manor Road | COW-004 | Cow Creek Road @ Cow Creek-1 (d/s) |
| WLB-006 | Rector Loop near turn | COW-003 | Cow Creek Road @ Cow Creek-2 |
| WLB-10 | Old Hwy 20 near Old Kimbro Road | COW-002 | Cow Creek Road @ Cow Creek-3 |
| WLB-009 | Parsons Road @ Willbarger Creek | COW-001 | Cow Creek Road @ Cow Creek-4 (u/s) |
| WLB-008 | Lockwood Road @ Trib to Willbarger Creek | | |
| WLB-011 | Jones Road @ Willbarger Creek | | ***Pedernales Tributary Watershed*** |
| WLB-012 | Bitting School Road @ Willbarger Creek | PDT-002 | Paleface Ranch Road at Cox Road |
| WLB-013 | Bitting School Road @ Trib to Willbarger Creek | PDT-001 | Paleface Ranch Road south of Cox Road |
| | Rolling Meadows area | | |

## Table 2-1.
## Preliminary Identified Problem Areas (Continued)

| East Travis County | | West Travis County | |
|---|---|---|---|
| | | | ***Fall Creek Watershed*** |
| | ***Lockwood Creek Watershed*** | FAL-001 | Fall Creek Road @ Fall Creek |
| | Quiet Oaks Lane area | | |
| | | | ***Lick Creek Watershed*** |
| | ***Gilleland Creek Watershed*** | LCK-001 | Pedernales Canyon Trail @ Lick Creek |
| | Taylor Lane near Decker Lake Road | | |
| | | | ***West Bee Creek Watershed*** |
| | ***Harris Branch Watershed*** | WBC-001 | Bee Creek Road @ Bee Creek |
| HRS-001 | Crystal Bend Drive @ Harris Branch | | Bee Creek Road near R O Drive |
| | | | |
| | ***Walnut Creek Watershed*** | | ***Cat Hollow Watershed*** |
| WLN-001 | Springdale Road @ Walnut Creek | LKT-012 | Bee Creek Road near Larkhall Drive |
| WLN-002 | Springdale Road @ Trib to Walnut Creek | | |
| | Pamela Heights | | ***Little Barton Creek Watershed*** |
| | Kings Village | LBA-001 | Great Divide Road @ Little Barton Creek |
| | | | |
| | ***Decker Creek Watershed*** | | ***Barton Creek Watershed*** |
| DKR-001 | Wells Trace @ Trib to Decker Creek | BAR-001 | Crumley Ranch Road @ Trib to Barton Creek |
| | | BAR-002 | D Morgan Road @ Trib to Barton Creek |
| | ***Colorado River Watershed*** | | |
| COL-001 | River Timber | | ***Slaughter Creek Watershed*** |
| | | SLA-002 | Rimstone Trail |
| | ***Onion Creek Watershed*** | SLA-001 | Weir Loop Circle @ Devil's Pen Creek (upper) |
| | Twin Creeks Park | SLA-003 | Weir Loop Circle @ Devil's Pen Creek (lower) |
| | Arroyo Doble | SLA-006 | Wyldwood Road @ Slaughter Creek |
| | | SLA-005 | Slaughter Creek Drive @ Trib to Slaughter Creek |
| | ***South Fork Watershed*** | SLA-007 | Ledgestone Terrace @ Trib to Pen Creek |
| | Thoroughbred Farms | | |
| | | | ***Williamson Creek Watershed*** |
| | ***Dry East Creek Watershed*** | WMS-001 | Weir Loop @ Williamson Creek |
| DRE-006 | Navarro Creek Rd @ Navarro Creek | WMS-002 | Pitter Pat Lane @ Williamson Creek |
| | Kellam Road area | WMS-003 | Mowinkle Drive @ Williamson Creek |
| | | | |
| | ***Maha Creek Watershed*** | | ***Lake Austin Trib Watershed*** |
| MAH-001 | Turnersville Road @ Maha Creek | LKA-001 | Tumbleweed Trail near Cuernavaca Drive |
| MAH-009 | Linden Road @ Maha Creek | LKA-003 | North Riverhills Road near Island Wood Road |
| MAH-002 | Evelyn Road @ Maha Creek - 2 low water crossings | | Del Gado Way |
| MAH-007 | Peterson Road @ Hwy 812 | | Austin Lake Estates |
| MAH-004 | Doyle Road @ Hokanson Road area | | |
| MAH-008 | Jacobson Road @ Maha Creek | | ***West Lake Trib Watershed*** |
| MAH-003 | Tom Sassman @ Maha Creek | WDT-001 | Westlake Drive near Woodcutters way |
| | Swiss Alpine Subdivision | | |
| | | | ***Bee Creek Watershed*** |

**Table 2-1.**
**Preliminary Identified Problem Areas (Concluded)**

| East Travis County | | West Travis County | |
|---|---|---|---|
| | ***Cowpen Watershed*** | BEE-001 | Wild Basin Street @ Unnamed Trib to Bee Creek |
| COW-001 | Williamson Road northwest of Elm Grove Road | | |
| COW-002 | Williamson Road southwest of Elm Grove Road | | ***Onion Creek Watershed*** |
| | | | Polk Road area |
| | ***Cedar Creek Watershed*** | | |
| | Laws Road @ Hwy 183 area | | ***Little Bear Creek Watershed*** |
| | | | Southwest Territory Subdivision |

Stream crossings both at major streams as well as minor tributaries were identified as frequent and dangerous flood problem areas. Many of the stream crossings are older structures intentionally designed to pass only minor storm events in what were previously sparsely populated areas. Some of theses areas have become more residentially developed, generating more traffic and increasing the potential danger at these low water crossings.

Several more densely populated areas within the unincorporated areas of the County were identified as frequent and dangerous flood problem areas. Flooding occurs in these areas from mostly minor watersheds. Most of these areas include older residential areas (subdivisions) lacking proper drainage infrastructure.

The preliminary problem areas identified were used as a starting point for the data collection effort and for evaluating and ultimately determining the highest priority areas.

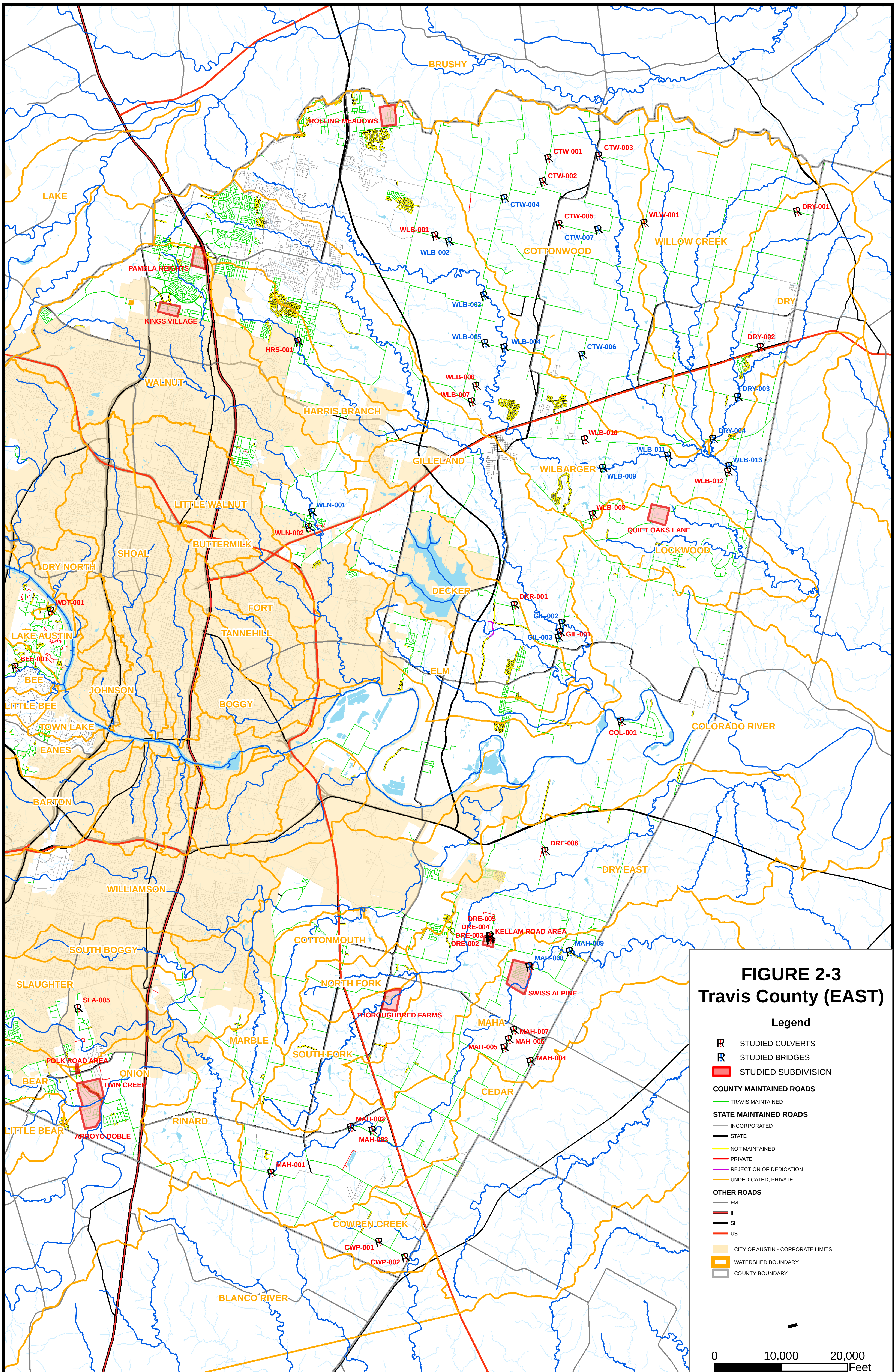


FIGURE 2-3
Travis County (EAST)
Legend
STUDIED CULVERTS
STUDIED BRIDGES
STUDIED SUBDIVISION
COUNTY MAINTAINED ROADS
TRAVIS MAINTAINED
STATE MAINTAINED ROADS
INCORPORATED
STATE
NOT MAINTAINED
PRIVATE
REJECTION OF DEDICATION
UNDEDICATED, PRIVATE
OTHER ROADS
FM
IH
SH
US
CITY OF AUSTIN - CORPORATE LIMITS
WATERSHED BOUNDARY
COUNTY BOUNDARY
0
10,000
20,000
Feet
BRUSHY
LAKE
ROLLING MEADOWS
CTW-001
CTW-003
CTW-002
CTW-004
DRY-001
CTW-005
WLW-001
CTW-007
WLB-001
WLB-002
WILLOW CREEK
COTTONWOOD
PAMELA HEIGHTS
KINGS VILLAGE
WLB-003
DRY
DRY-002
WLB-005
WLB-004
CTW-006
HRS-001
WALNUT
DRY-003
WLB-006
WLB-007
HARRIS BRANCH
DRY-004
WLB-010
WLB-011
WLB-013
GILLELAND
WILBARGER
WLB-009
WLB-012
LITTLE WALNUT
WLN-001
WLB-008
QUIET OAKS LANE
WLN-002
BUTTERMILK
SHOAL
LOCKWOOD
DRY NORTH
DECKER
WDT-001
DKR-001
FORT
GIL-002
TANNEHILL
GIL-003
GIL-001
LAKE AUSTIN
BEE-001
ELM
BEE
JOHNSON
LITTLE BEE
BOGGY
COL-001
COLORADO RIVER
TOWN LAKE
EANES
BARTON
DRE-006
DRY EAST
WILLIAMSON
DRE-005
DRE-004
KELLAM ROAD AREA
DRE-003
DRE-002
COTTONMOUTH
MAH-009
MAH-008
SOUTH BOGGY
NORTH FORK
SWISS ALPINE
SLAUGHTER
SLA-005
THOROUGHBRED FARMS
MAHA
MAH-007
MAH-006
MARBLE
MAH-005
MAH-004
POLK ROAD AREA
SOUTH FORK
ONION
BEAR
TWIN CREEK
CEDAR
RINARD
LITTLE BEAR
ARROYO DOBLE
MAH-002
MAH-003
MAH-001
COWPEN CREEK
CWP-001
CWP-002
BLANCO RIVER

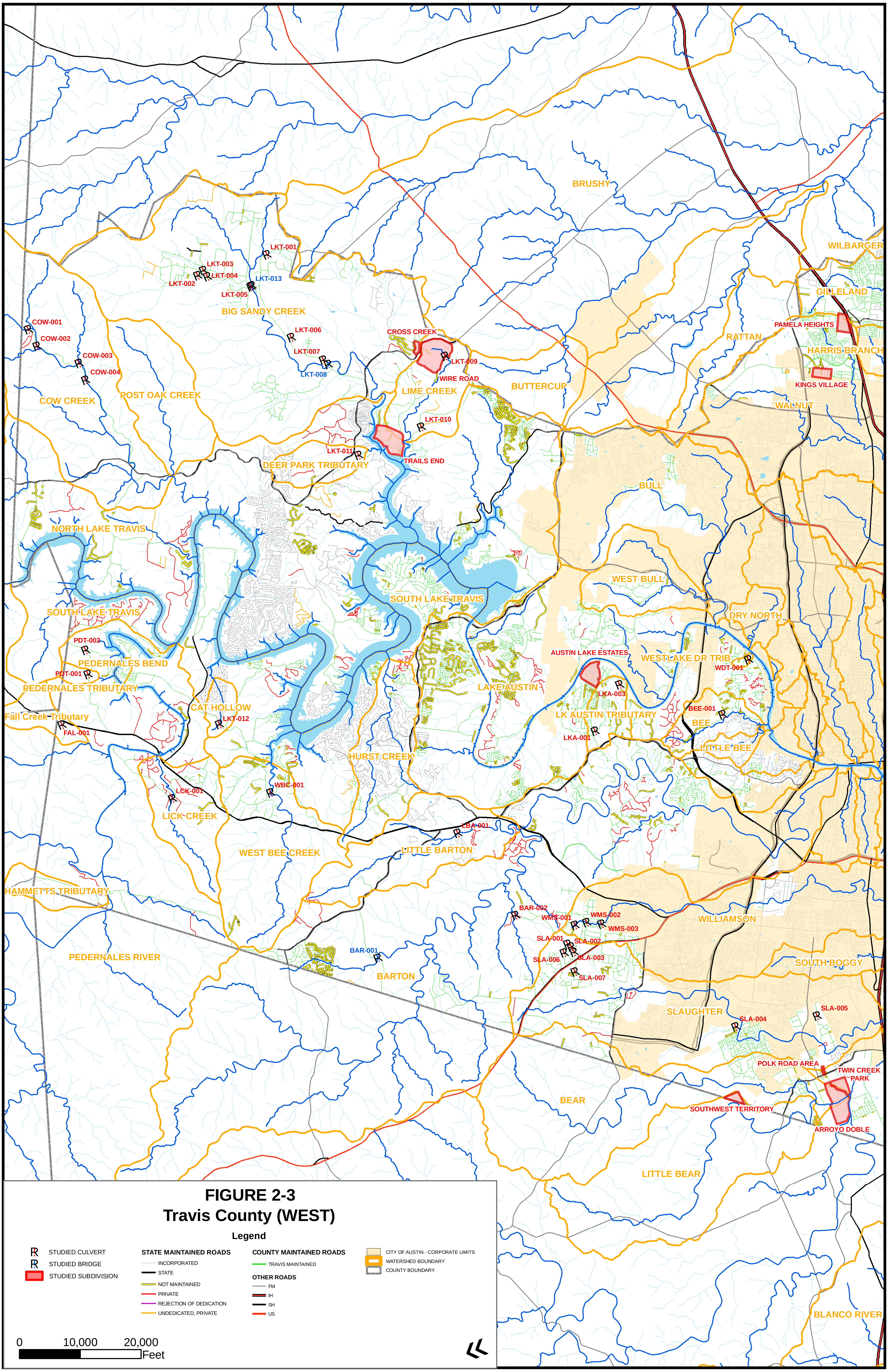



**FIGURE 2-3**
**Travis County (WEST)**

# Section 3
# Preliminary Problem Area Ranking

## 3.1 Data Collection

An extensive collection of data was gathered for this study. The types of data collected included three general categories:

- Field data,
- Digital geographic information, and
- Record data.

The types and sources of data collected are described in more detail below.

### 3.1.1 Field Data

Field data collected for this study included field reconnaissance data from engineering staff and topographic field survey data. Field reconnaissance was performed by HDR engineering staff for all of the preliminarily identified problem areas. Topographic surveys were performed on the 45 highest priority stream crossings and 12 priority subdivision areas, as determined by the preliminary ranking process described subsequently in this section.

Field reconnaissance at each problem area entailed visual inspections and documentation, photographic surveys, and observations of actual flooding from storm events where possible. Visual inspections were conducted at each stream crossing to assess the physical condition of each drainage structure, state of erosion and/or sedimentation, and level of debris clogging present. A sample Field Reconnaissance Report is shown in Figure 3-1. The sites were also observed for potential habitable structures threatened by

**Field Reconnaissance Report — Culvert**

| | | | |
|---|---|---|---|
| **Structure ID:** | SLA-005 | **Inspection Date & Time:** | 5/25/07 5:10 pm |
| **Stream Name:** | Slaughter Creek Trib | **Company:** | HDR |
| **Street Name:** | Slaughter Creek Dr | **Inspected by:** | E. Stewart |
| **Location:** | | | |

**Structure Information:**

| | | | | | |
|---|---|---|---|---|---|
| **Type:** | CC | **Barrel Num:** | 2 | **Dia/Span/Rise:** | |
| **Shape:** | Circ | **Material:** | CMP | **Condition:** | Slightly impaired |

| **UPSTREAM** | | **DOWNSTREAM** | |
|---|---|---|---|
| **End Treatment:** | PP | **End Treatment:** | PP |
| **Condition:** | Satisfactory | **Condition:** | Impaired |
| **Erosion Cond:** | Minor | **Erosion Cond:** | Moderate |
| **Sediment Cond:** | None | **Sediment Cond:** | None |

| | | | |
|---|---|---|---|
| **Road Material:** | Paved | **Road Condition:** | Good |
| **General Notes:** | | | |

**Reconnaissance Notes:**
-Creek is rock bed controlled. Heavily wooded creek; FP upstream of culverts
-Downstream roadway embankment has been repair numerous times with concrete and asphalt. Downstream embankment left and right of culvert is severely eroded.
-Asphalt pavement observed in creek downstream
-Speed limit 35 mph
Utility pole conflict at LB

| Photo Number | Direction Facing | Description |
|---|---|---|
| | | 12 photos take, saved to project drive. |
| | | |
| | | |
| | | |
| | | |

**Note:** 1) File names for photographs must later be renamed in accordance with the County's Guidelines and Specifications.
2) For "Direction Facing" use abbreviations such as N, NE, ENE, etc.

*Slaughter Creek* HDR

**Figure 3-1. Sample Field Reconnaissance Report**

flooding at each problem area. This qualitative information was used in the preliminary ranking process described in the subsequent section.

During each site visit, a digital photographic survey was taken of the drainage structures and their surroundings. At a minimum, the upstream and downstream ends of drainage structures, upstream and downstream channels, and road profiles were photographed, as shown in the example below (Figure 3-2).

***Figure 3-2. Sample Field Recon Photos, Gregg Lane at Wilbarger Creek***

Several significant storm events occurred during the field reconnaissance effort which was mostly performed throughout calendar year 2007. The year 2007 was one of the wettest years on record for the Travis County area including a new record rainfall total for the month of June. Photographs were taken of several problem areas while minor to moderate flooding was occurring during some of the more significant storm events, as shown in Figure 3-3. The observed flooding was helpful in determining the nature of the flooding at the identified problem areas, however, the observed flooding was not sufficient to perform detailed calibration of hydrologic and hydraulic models.


***Figure 3-3. Gregg Lane at Wilbarger Creek***

A topographic field survey was performed at each of the selected priority problem areas. The purpose of the survey was to provide topographic and planimetric information sufficient for performing hydraulic analyses and developing conceptual design alternatives. The topographic surveys were not intended to be used for final design. The surveys were based on Texas State Plane Coordinates Central Zone NAD83 for horizontal control and NAVD 88 for vertical control, in U.S. Survey Feet. Recoverable benchmarks were set at each problem area site for future use in design and construction of any recommended improvements.

### 3.1.2 Digital Geographic Information

Digital geographic information collected for this study included aerial photography, elevation contours, soils data, hydrography, roadways, and property parcel line work. GIS data sets were obtained primarily from Travis County, the City of Austin, and the Texas Natural Resources Information System (TNRIS). The following is a list of the data and data sources used for this study:

- Year 2006 6-inch resolution aerial photography – Travis County, City of Austin
- Year 2003 6-inch resolution aerial photography – City of Austin
- Year 2003 2 foot contours of the City of Austin and ETJ – City of Austin
- 10 foot contours – USGS, obtained from TNRIS
- SSUGRO Soil Survey data – NRCS, obtained from TNRIS
- Travis County Roads – Travis County
- Other Roads – TxDOT, City of Austin
- FEMA SFHA mapping – City of Austin
- Travis County parcels – Travis County Appraisal District (TravisCAD)
- National Hydrography Dataset (NHD) – USGS and the Environmental Protection Agency (EPA), obtained from TNRIS

### 3.1.3 Record Data

Record data obtained for this study included paper documents from the Travis County file archives, recorded plats from the Travis County Plat Records, and Travis County Emergency Response Team (ERT) call-in log data. Record data in non-digital format was scanned to PDF for inclusion as part of the electronic deliverable to the County.

The Travis County file archives were searched for documents pertaining to identified flood problems areas. Documents found included various design and construction drawings, plat information, easement documentation, topographic surveys, and floodplain property acquisition information. Overall, the file archives yielded a limited amount of data.

Recorded subdivision plats were obtained from the Travis County Plat Records. The subdivision plats provided information about existing drainage easements within the identified problem areas and adjacent to some of the identified problem stream crossings.

Travis County Emergency Response Team call-in logs were obtained. The call-in logs provide a record of individual call-ins from ERT staff related to emergency situations including flood water over roads and road closures due to flooding. The log data spans a period starting from June of 2000 to July of 2007. Each call-in logged includes a location, status, date, and time as shown in Figure 3-4. The location fields were searched for street names that match those included in the identified problem areas. The status fields were then searched for flood related descriptions as shown. The ERT call-in log data provided evidence of flood problems at many identified problem areas. The absence of flood related call-ins in other identified problem areas, however, were not automatically construed as evidence that flooding was absent in such areas.

| location | unit | status | date | time |
|---|---|---|---|---|
| ALBERT VOLKER WATER OVER THE ROAD SIGNS | RM132 | Weather related | 11/22/2004 | 6:35:55 AM |
| ALBERT VOELKER - REMOVING SIGNS TO THE SIDE OF THE ROAD | RM147 | Weather related | 11/23/2004 | 12:16:38 PM |
| ALBERT VOLKER AND COUNTY LINE BARRICADES ARE UP | RM478 | Weather related | 11/22/2004 | 1:04:57 PM |
| | | | | |
| BITTING SCHOOL ROAD/ERT Resp to Water Over RD | 20070113 | 20070113 | PCT1 | 8515 |
| BITTING SCHOOL ROAD/ERT Resp to Water Over RD | 20070327 | 20070327 | PCT1 | 8515 |
| BITTING SCHOOL ROAD | RM139 | WATER SIGNS | 11/23/2004 | 12:43:53 PM |
| BITTING SCHOOL WATER | RM92 | MSG | 1/29/2001 7:20 | |
| BITTINGS SCHOOL RD | RM163 | MSG | 3/28/2001 12:57 | |
| BITTINGSCHOOL ROAD AT HOG EYE HIGH WATER SIGNS | RM92 | MSG | 11/15/2001 20:48 | |
| CLOSED BITTING SCHOOL ROAD TO CLEAN OUT FLOOD GATE | RM154 | MSG | 1/29/2001 8:33 | |

***Figure 3-4. Sample ERT Call-In Log***

### *3.1.4 Data Management*

The data collected during the study as described above was cataloged into a comprehensive digital data set included as a deliverable to the County as part of this study. The data collected is provided to the County in digital format in a comprehensive and organized data set and GIS geodatabase. The data is organized by watershed corresponding to the watersheds evaluated in the study. Each problem area within a studied watershed contains a standardized folder structure as shown in Figure 3-5.

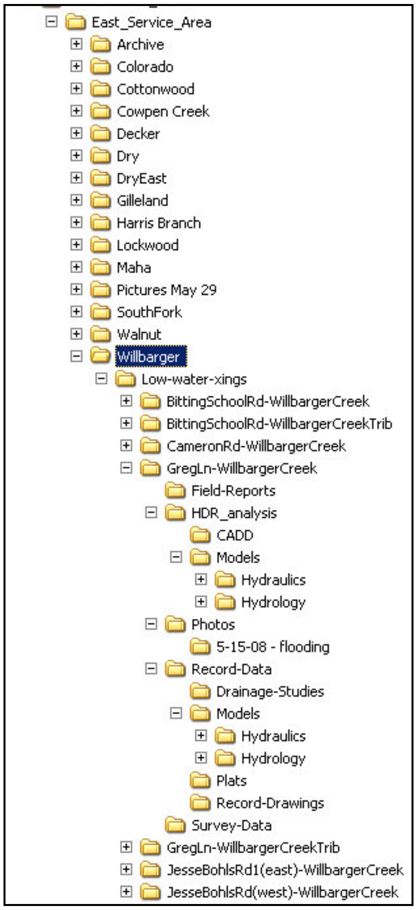



***Figure 3-5. Standard Folder Structure***

The geodatabase includes points for each identified problem area. Each point includes attributes and fields pertaining to the data collected during field reconnaissance. The point attributes and fields were developed in close coordination with the County to match the County's existing MS4 drainage infrastructure geodatabase. The geodatabase developed from this study includes hyperlinks to the data set for each problem area.

## *3.2 Preliminary Ranking Process*

Each problem area was evaluated against specific criteria. The criteria were weighted according to their relative importance in assessing the need to address issues at each problem area. Each problem area was then assigned a score for each criterion. The total score for each problem area was computed as the sum of the products of the criteria scores and the criteria weights. The problem areas were then ranked for inclusion in the study on the basis of the total scores.

## *3.3 Preliminary Stream Crossing Evaluation Criteria*

Each stream crossing was evaluated against ten criteria. Nine of the ten evaluation criteria measured functionality of the crossing and severity of various possible problems that may exist at the crossing. A tenth criterion considered whether repair of the crossing could be included with currently planned roadway improvement projects. The criteria were selected based on discussion with County staff and experience with previous studies. Table 3-1 lists the evaluation criteria.

### *3.3.1 Criteria Weighting*

The ten criteria listed in Table 3-1 were assigned weights according to their relative importance in assessing problems at stream crossings. The weights were established through a

**Table 3-1.**
**Preliminary Stream Crossing Evaluation Criteria**

| ID. | Description |
|---|---|
| C1. | Size of Waterway (measured by watershed area) |
| C2. | Frequency of Reported Road Closures |
| C3. | Impacts to Emergency Access Under Existing Conditions |
| C4. | Existing Facility Condition |
| C5. | Severity of Existing Sediment Condition |
| C6. | Ratio of Structure Opening Area to Drainage Area |
| C7. | Threat to Adjacent Upstream Habitable Structures |
| C8. | Severity of Existing Debris Condition |
| C9. | Could Improvement Project be Combined with Roadway Project? |
| C10. | Severity of Existing Erosion Condition |

pair-wise comparison process. Members of County and HDR engineering staff were asked individually to compare each criterion to all other criteria, making a judgment as to whether that criterion was more important than each of the other criteria. The criterion was assigned a value of 1.0 for each criterion that it was judged to be more important than and the assigned values were totaled. A criterion that was more important than all the others would receive a total value of 9 and a criterion that was less important than all the others would receive a total value of 0. Individual staff member's criteria weights were then computed by dividing each of the total values by the total number of comparisons that were made (45), so that the sum of all the criteria weights was 1.0. HDR engineering staff members' weights were averaged. The HDR staff average weights were then combined with the individual County staff members' weights to provide overall average weights. Lastly, judgment was used to make minor adjustments to the overall average weights, producing the final criterion weights used for the crossing prioritization. Table 3-2 lists the final criteria weights, with the criteria ranked in order from highest weight (most important) to lowest (least important).

As shown in Table 3-2, the criteria receiving the highest weights are directly related to public safety: impacts to emergency access and threat to habitable structures. The criterion receiving the lowest weight was the size of waterway, as flood flows in a small waterway may still cause significant overtopping if a structure is undersized.

***Table 3-2.***
***Stream Crossing Evaluation Criteria Weights***

| ID. | Description | Weight | Criterion Rank |
|---|---|---|---|
| C3. | Impacts to Emergency Access Under Existing Conditions | 0.20 | 1 |
| C7. | Threat to Adjacent Upstream Habitable Structures | 0.17 | 2 |
| C2. | Frequency of Reported Road Closures | 0.15 | 3 |
| C4. | Existing Facility Condition | 0.12 | 4 |
| C6. | Ratio of Structure Opening Area to Drainage Area | 0.10 | 5 |
| C10. | Severity of Existing Erosion Condition | 0.09 | 6 |
| C9. | Could Improvement Project be Combined with Roadway Project? | 0.06 | 7 |
| C8. | Severity of Existing Debris Condition | 0.05 | 8 |
| C5. | Severity of Existing Sediment Condition | 0.04 | 9 |
| C1. | Size of Waterway (measured by watershed area) | 0.02 | 10 |

### 3.3.2 Stream Crossing Problem Area Scoring

Each crossing on the preliminary list was scored on a scale of 0 to 4 for each criterion. The basis of the scoring for each criterion is described in the following sections. Scoring for each stream crossing was based on the data collected as described in the subsequent section.

#### 3.3.2.1 Size of Waterway

The size of the waterway was quantified by the size of the area draining to the crossing. Drainage areas to all the crossings on the preliminary list were delineated based on City of Austin 2-foot contour data where available and United States Geological Survey (USGS) quadrangle map contour data in areas not covered by the City of Austin data. Larger drainage areas received a higher score than smaller drainage areas. Table 3-3 lists the drainage area ranges associated with the scores of 0 to 4.

***Table 3-3.***
***Scoring for Criterion C1 Size of Waterway***

| Score | Drainage Area Range |
|---|---|
| 0 | < 64 acres |
| 1 | ≥ 64 acres but < 320 acres |
| 2 | ≥ 320 acres but < 640 acres |
| 3 | ≥ 640 acres but < 1280 acres |
| 4 | ≥ 1280 acres |

#### *3.3.2.2 Frequency of Reported Road Closures*

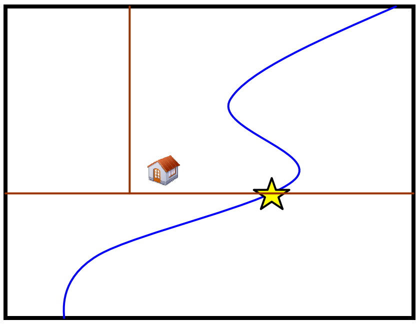
Data for scoring the frequency of road closures criterion was obtained from County ERT call-in log records. The records logged instances occurring since June of 2000 in which roads were closed due to flooding at a particular crossing, as described in the preceding section regarding Data Collection. Table 3-4 lists the scores associated with the number of road closures occurring at a particular crossing since June 2000.

***Table 3-4.***
***Scoring for Criterion C2 Frequency of Reported Road Closures***

| ***Score*** | ***Number of Road Closures Since June, 2000*** |
|---|---|
| 0 | 0 closures |
| 1 | |
| 2 | 1 closure |
| 3 | |
| 4 | More than 1 closure |

#### *3.3.2.3 Impacts to Emergency Access Under Existing Conditions*

The impacts to emergency access under existing conditions criterion assessed the number of habitable structures to which access would be impacted if restricted due to flooding at a particular crossing, as well as the number of alternative access routes that exist to the structures. The most recent aerial photography was used to assess the location of structures relative to the crossings. Access routes were identified with Travis County and Texas Department of Transportation GIS data showing road locations. Assessments of whether structures were habitable were made based on review of aerial photography and observations in the field. Furthermore, the scores were assigned based on conditions existing at the time of the study, without any improvements to the crossing or addition of alternative access routes. Figures 3-6a through 3-6e explain the basis for the assignment of scores for this criterion.



**Score: 0**

**Multiple alternative access routes (to one or more habitable structures) exist which are not subject to flooding. Access routes have no stream crossings.**

**Legend**

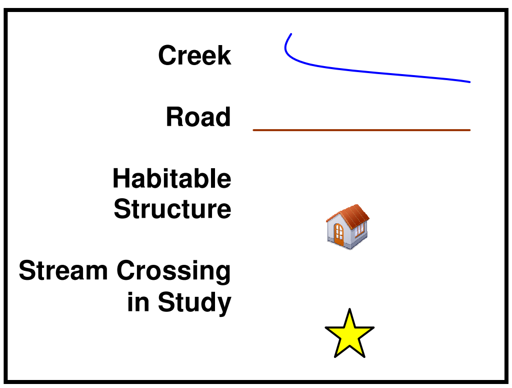
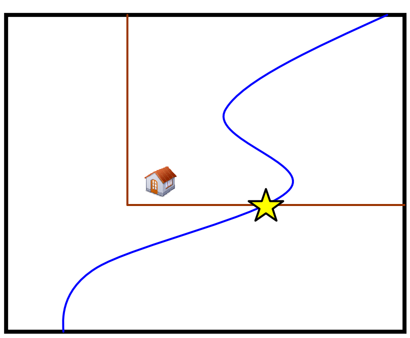


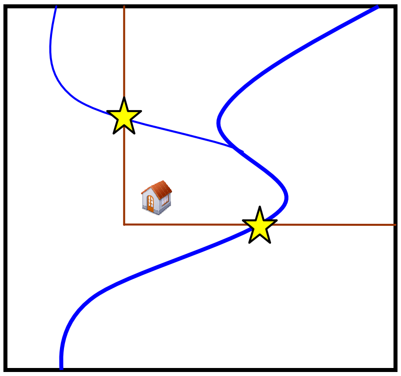

***Figure 3-6a. Impacts to Emergency Access Under Existing Conditions - Score: 0***



**Score: 1**

**One alternative access route (to one or more habitable structures) exists which is not subject to flooding (i.e. the access route has no stream crossings).**

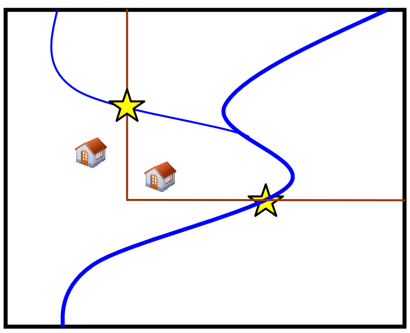
***Figure 3-6b Impacts to Emergency Access Under Existing Conditions - Score: 1***



**Score: 2**

**Complete access to one habitable structure is cut off by flooding. The alternative access route or routes include(s) stream crossings that are on the preliminary list of study crossings.**

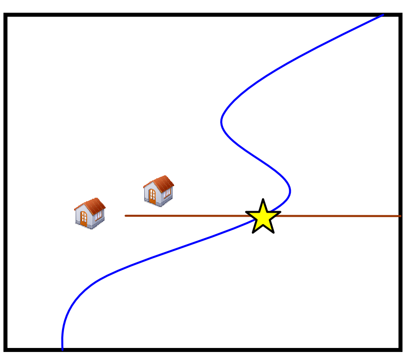
***Figure 3-6c. Impacts to Emergency Access Under Existing Conditions - Score: 2***



**Score: 3**

**Complete access to more than one habitable structure is cut off by flooding. The alternative access route or routes include(s) stream crossings that are on the preliminary list of study crossings.**

***Figure 3-6d Impacts to Emergency Access Under Existing Conditions - Score: 3***



**Score: 4**

**Complete access to more than one habitable structure is cut off by flooding. No alternative access exists.**

***Figure 3-6e Impacts to Emergency Access Under Existing Conditions - Score: 4***

#### *3.3.2.4 Existing Facility Condition*

The existing facility condition criterion assesses the structural condition of the crossing, addressing whether damage to the culvert or bridge structure is impairing its ability to convey flow. The condition of the crossing was assessed during the site visit. The basis for scoring this criterion is listed in Table 3-5.

***Table 3-5.***
***Scoring for Criterion C4 Existing Facility Condition***

| *Score* | *Facility Condition* |
|---|---|
| 0 | New - built within the last five years |
| 1 | Satisfactory - not new, but fully functional |
| 2 | |
| 3 | Impaired - ability to convey flow is impaired |
| 4 | Failing - structure does not convey flow |

#### *3.3.2.5 Severity of Existing Sediment Condition*

The severity of existing sediment condition criterion assesses whether sediment accumulation immediately up- or downstream of the crossing is impairing its ability to convey flow. The sediment condition was assessed during the site visit. The basis for scoring this criterion is listed in Table 3-6.

***Table 3-6.***
***Scoring for Criterion C5 Severity of***
***Existing Sediment Condition***

| *Score* | *Sediment Condition* |
|---|---|
| 0 | None |
| 1 | Minor |
| 2 | |
| 3 | Moderate |
| 4 | Severe - sediment severely restricts flow |

#### *3.3.2.6 Ratio of Drainage Area to Structure Opening Area*

The ratio of drainage area to structure opening area criterion assess the size of the bridge or culvert opening relative to the size of the area draining to the crossing. The purpose of the criterion is to provide a preliminary indication of whether the crossing may be undersized. The basis for scoring this criterion is listed in Table 3-7.

**Table 3-7.**
**Scoring for Criterion C6 Ratio of Drainage Area to Structure Opening Area**

| Score | Eastern Travis County Ratio of Drainage Area to Structure Opening Area (ac/ft2) | Western Travis County Ratio of Drainage Area to Structure Opening Area (ac/ft2) |
|---|---|---|
| 0 | ≤ 8.0 | ≤ 7.1 |
| 1 | | |
| 2 | >8 and ≤20 | > 7.1 and ≤180 |
| 3 | | |
| 4 | > 20 | > 180 |

The structure opening area was estimated based visual observations made during the site visit. In some cases, the structure opening was submerged or partially blocked by sediment, lending additional uncertainty to the area estimate. Detailed surveys of the structures were not made until later in the study, once the preliminary crossing list had been scored and the crossings had been prioritized. Drainage areas to all the crossings on the preliminary list were delineated based on City of Austin 2-foot contour data where available and United States Geological Survey (USGS) quadrangle map contour data in areas not covered by the City of Austin data.

The drainage area to structure opening area ratio limits used in the scoring were established by first selecting a threshold runoff rate that a structure could be expected to pass at a reasonable average flow velocity. This runoff rate was set to be the runoff rate produced by the City of Austin 2-year, 30-minute rainfall intensity (2.64 in/hr) falling on undeveloped pasture or rangeland. The rainfall rate was converted to a runoff rate using a Rational Method runoff coefficient. Because the west side of the County has steeper topography than the east, a runoff coefficient value appropriate for steeper terrain was used to compute the runoff rate for the west side of the County (0.37), while a value representative of flatter terrain was used for the east (0.33). The runoff rates in inches per hour were then converted to rates in cubic feet per second per acre (0.88 cfs/ac for the east and 0.98 cfs/ac for the west). A maximum acceptable crossing average through flow velocity of 7.0 ft/sec was selected. Using these parameters, a minimum required structure size for a given drainage area could then be computed as the runoff rate in cubic feet per second per acre multiplied by the drainage area in acres and then divided by the maximum acceptable velocity. The maximum allowable drainage area to structure area ratio in acres per square foot would then be computed as the drainage area divided by the minimum structure area. Because the drainage area cancels out in this computation, this ratio can also be computed as the maximum acceptable crossing velocity in feet per second divided by the runoff rate in cubic feet per second per acre. For the east side of the County the ratio was computed to be 8.0 and for the west side of the County it was computed to be 7.1.

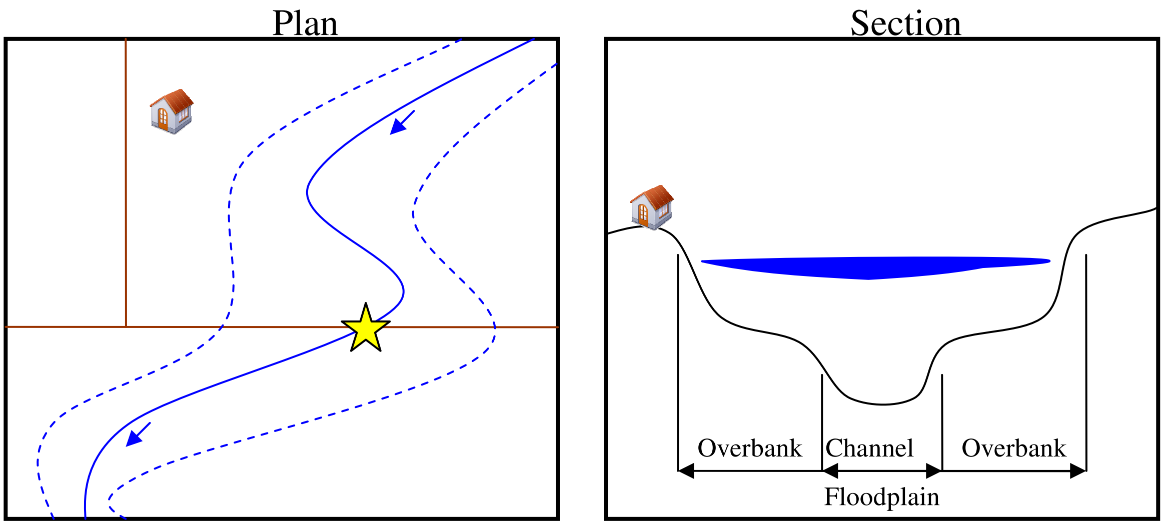
If the drainage area to structure area ratio for a crossing was computed to be equal to or below these values, the crossing was assigned a score of 0 for this criterion. Crossings with drainage area to structure area ratios greater then the threshold values of 8.0 for the east side of the County and 7.1 for the west were then assigned a score of either 2 or 4, depending on whether their ratio values were above or below the median ratio value for that side of the county. The median ratio for the east side of the County was computed to be approximately 20 ac/ft$^2$ and the median ratio for the west side of the County was computed to be approximately 180 ac/ft$^2$.

#### *3.3.2.7 Threat to Adjacent Upstream Habitable Structures*

The threat to adjacent upstream habitable structures criterion assesses the proximity of habitable structures to the floodplain upstream of the crossing. The criterion provides a preliminary screening to identify areas in which improvements to crossings may reduce upstream habitable structure flooding. Conversely, it also identifies potential areas in which raising the road profile to reduce roadway overtopping frequency without providing sufficient additional capacity to prevent an increase in upstream flood elevations may result in an increase in habitable structure flooding. The assessment made by this criterion is at a preliminary screening level only as a detailed hydraulic analysis at each crossing would be required to make a complete assessment of the impacts of a given crossing on upstream structure flooding.

Figures 3-7a through 3-7d explain the basis for the assignment of scores for this criterion. Floodplain and floodway locations were identified using preliminary floodplain mapping from the Travis County FEMA restudy. Aerial photography was used to assess the location of structures relative to the crossings and floodplains. Assessments of whether structures were habitable were made solely on review of aerial photography. For streams not included in the

FEMA restudy, the main channel and overbank locations were estimated from available topography, either City of Austin 2-foot contours or the (USGS) quadrangle map contours.




**Score: 0**
**No habitable structures are located directly upstream of the low water crossing in the channel or overbanks (i.e. there are no habitable structures in the FEMA Zone A, FEMA Zone AE, or area of suspected flood impact).**

Legend

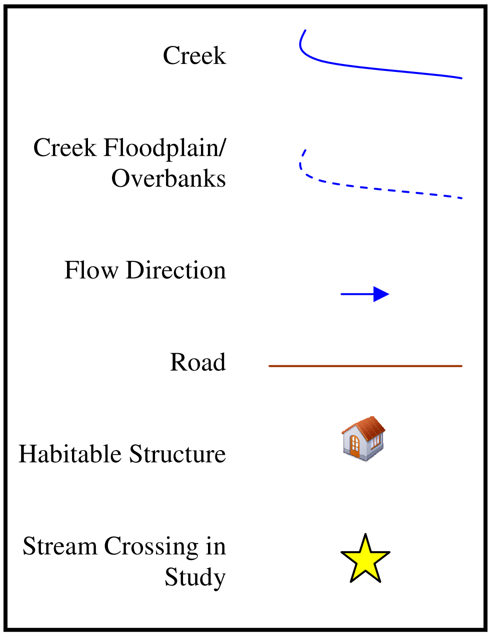
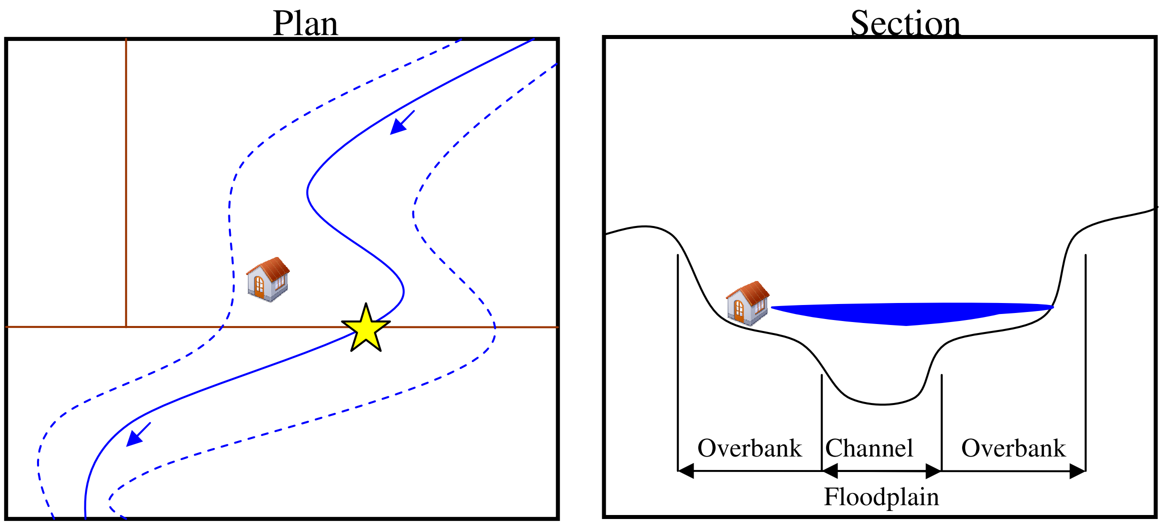



***Figure 3-7a Threat to Adjacent Upstream Habitable Structures - Score: 0***




**Score: 2**
**One habitable structure is located within the upstream channel overbank (i.e. there is one habitable structure in the FEMA Zone A, FEMA Zone AE, or area of suspected flood impact and outside the floodway or channel).**

***Figure 3-7b Threat to Adjacent Upstream Habitable Structures- Score: 2***

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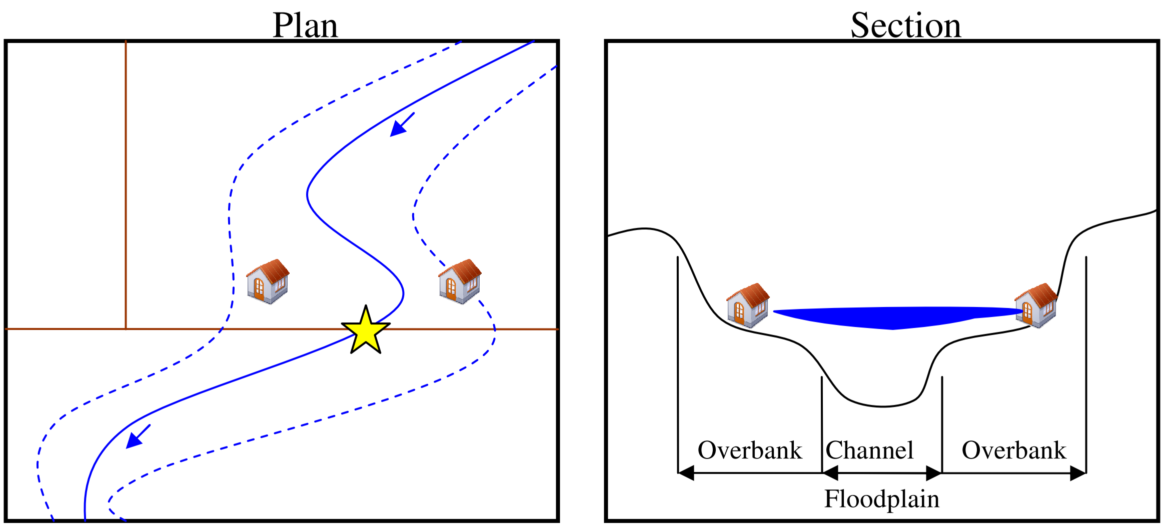
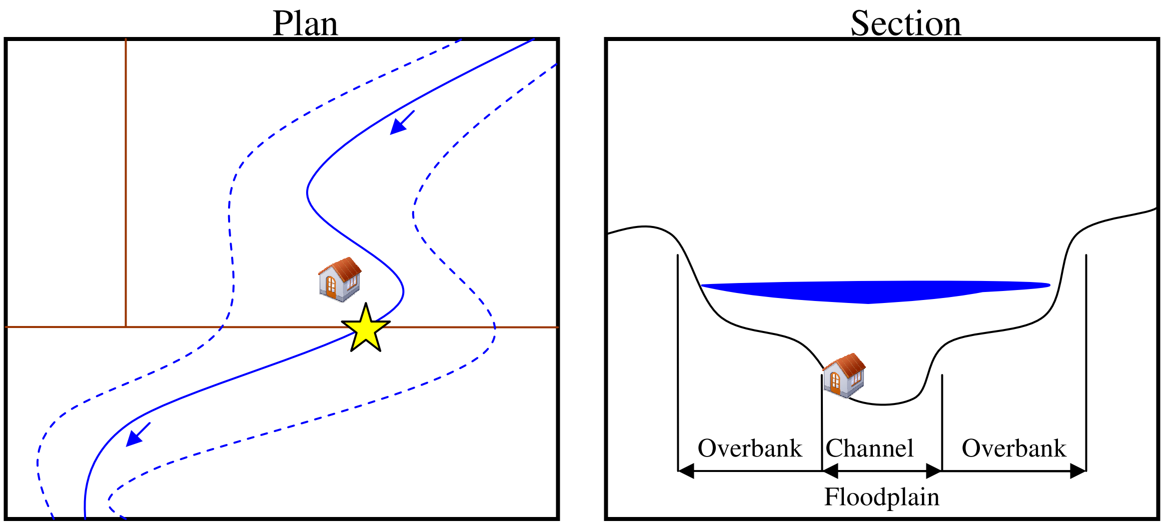



**Score: 3**
**More than one habitable structure is located within the upstream channel overbanks (i.e. there is one or more habitable structures in the FEMA Zone A, FEMA Zone AE, or area of suspected flood impact and outside the floodway or channel).**

***Figure 3-7c Threat to Adjacent Upstream Habitable Structures- Score: 3***




**Score: 4**
**One or more habitable structures are located within the upstream channel (or within the FEMA floodway). Channel location to be confirmed by visible inspection of contour data.**

***Figure 3-7. Threat to Adjacent Upstream Habitable Structures- Score: 4***

#### *3.3.2.8 Severity of Existing Debris Condition*

The severity of existing debris condition criterion assesses whether debris accumulation immediately up- or downstream of the crossing is impairing its ability to convey flow. The debris condition was assessed during the site visit. The basis for scoring this criterion is listed in Table 3-8.

***Table 3-8.***
***Scoring for Criterion C8 Severity of Existing Debris Condition***

| *Score* | *Debris Condition* |
|---|---|
| 0 | None |
| 1 | Minor |
| 2 | |
| 3 | Moderate |
| 4 | Severe - sediment severely restricts flow |

### *3.3.2.9 Could Improvement Project be Combined with Roadway Project?*

This criterion assesses whether improvements to a stream crossing could be combined with other planned improvements to the road. The other improvements may be part of the bond program or part of the 2008 Road Work Plan. Crossings located on roads with planned improvements received higher scores for this criterion, as prioritization of crossings with planned road improvement projects may offer potential cost savings if work on the crossing and roadway could be performed together.

***Table 3-9.***
***Scoring for Criterion C9 Could Improvement Project be Combined with Roadway Project***

| *Score* | *Roadway Project Status* |
|---|---|
| 0 | No roadway project planned |
| 1 | |
| 2 | |
| 3 | Roadway project included in bond program |
| 4 | Roadway is listed on 2008 Road Work Plan |

### *3.3.2.10 Severity of Existing Erosion Condition*

The severity of existing erosion condition criterion assesses whether erosion immediately upstream or downstream of the crossing is threatening the structure. The erosion condition was assessed during the site visit. The basis for scoring this criterion is listed in Table 3-10.

***Table 3-10.***
***Scoring for Criterion C10 Severity of Existing Erosion Condition***

| *Score* | *Erosion Condition* |
|---|---|
| 0 | None |
| 1 | Minor |
| 2 | |
| 3 | Moderate |
| 4 | Severe – erosion severely threatens integrity of structure |

### *3.3.3 Preliminary Stream Crossing Ranking*

The total score for each crossing was computed as the sum of the products of the criteria scores and the criteria weights. Table 3-11 lists each crossing's score for each criterion as well as each crossing's total score. The highest total score a crossing could receive is a value of 4.0, indicating severe problems at the crossing and a high prioritization for further study and improvement. Table 3-11 lists the crossings ranked from highest total score to lowest, providing a prioritized crossing list. The 45 highest scoring crossings were included for hydrologic and hydraulic evaluation in the next phase of the study.

**Table 3-11.**
**Preliminary Stream Crossing Problem Area Ranking**

| Prelim Rank | Problem Area by Watershed | Crossing ID | Criteria Scoring | | | | | | | | | | Total Score Based on Weighted Criteria |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | C1 Size of Waterway | C2 Number of Reported Road Closures | C3 Impacts to Emergency Access Under Existing Conditions | C4 Existing Facility Condition | C5 Severity of Existing Sediment Condition | C6 Ratio of Drainage Area to Structure Opening Area | C7 Threat to Adjacent Upstream Habitable Structures | C8 Severity of Existing Debris Condition | C9 Could Improvement Project Be Combined With Roadway Project? | C10 Severity of Existing Erosion Condition | |
| | **Criteria Weights** | | **0.02** | **0.15** | **0.20** | **0.12** | **0.04** | **0.10** | **0.17** | **0.05** | **0.06** | **0.09** | |
| 1 | Fall Creek Road near Hwy 71 | FAL-001 | 4 | 4 | 4 | 3 | 1 | 4 | 2 | 3 | 0 | 3 | 3.05 |
| 2 | Great Divide Road | LBA-001 | 4 | 4 | 4 | 3 | 3 | 4 | 0 | 3 | 0 | 1 | 2.60 |
| 3 | Pedernales Canyon Trail near Little Creek Trail | LCK-001 | 4 | 4 | 4 | 1 | 1 | 2 | 0 | 3 | 0 | 3 | 2.27 |
| 4 | Navarro Creek Rd @ Navarro Creek | DRE-006 | 3 | 2 | 4 | 1 | 0 | 4 | 3 | 1 | 0 | 0 | 2.25 |
| 5 | Tom Sassman Road @ Maha Creek | MAH-003 | 4 | 4 | 1 | 1 | 1 | 4 | 3 | 1 | 0 | 1 | 2.11 |
| 6 | Wyldwood Road @ Slaughter Creek | SLA-004 | 4 | 4 | 4 | 1 | 1 | 4 | 0 | 1 | 0 | 0 | 2.10 |
| 7 | Felder Lane @ Cottonwood Creek | CTW-003 | 3 | 2 | 1 | 3 | 4 | 4 | 0 | 1 | 4 | 3 | 2.03 |
| 8 | Jesse Bohls Road - East Crossing | WLB-002 | 4 | 4 | 3 | 1 | 0 | 4 | 0 | 0 | 3 | 0 | 1.99 |
| 9 | Big Sandy Dr near Round Mountain Dr | LKT-005 | 4 | 2 | 1 | 1 | 4 | 4 | 2 | 0 | 0 | 4 | 1.97 |
| 10 | Linden Road @ Maha Creek | MAH-009 | 4 | 4 | 1 | 1 | 1 | 4 | 3 | 0 | 0 | 0 | 1.97 |
| 11 | Tumbleweed Trail near Cuernavaca Drive | LKA-001 | 1 | 0 | 4 | 1 | 1 | 2 | 2 | 1 | 0 | 4 | 1.93 |
| 12 | Nameless Road @ trib to Big Sandy | LKT-006 | 2 | 2 | 1 | 3 | 4 | 2 | 0 | 4 | 0 | 4 | 1.81 |
| 13 | Gregg Lane @ Willbarger Creek | WLB-004 | 4 | 4 | 3 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 1.81 |
| 14 | Juniper Trail | LKT-004 | 4 | 0 | 4 | 1 | 0 | 4 | 0 | 0 | 0 | 4 | 1.76 |
| 15 | Jacobson Road near Alpine Drive | MAH-008 | 4 | 4 | 0 | 1 | 0 | 4 | 3 | 0 | 0 | 0 | 1.73 |
| 16 | Round Mountain Rd near Big Sandy Dr | LKT-013 | 4 | 0 | 4 | 1 | 0 | 0 | 2 | 0 | 0 | 4 | 1.70 |
| 17 | Bee Creek Road @ Bee Creek | WBC-001 | 4 | 4 | 1 | 1 | 3 | 4 | 0 | 3 | 0 | 0 | 1.68 |
| 18 | Nameless Road north of Honeycomb Drive | LKT-001 | 2 | 2 | 3 | 1 | 1 | 2 | 0 | 1 | 0 | 3 | 1.62 |
| 19 | Slaughter Creek Drive @ Trib to Slaughter Creek | SLA-005 | 2 | 4 | 3 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 1.57 |
| 20 | Caldwell Ln @ River Timber Dr | COL-001 | 0 | 0 | 4 | 0 | 0 | 4 | 2 | 0 | 0 | 0 | 1.55 |
| 21 | Parsons Road @ Willbarger Creek | WLB-009 | 4 | 4 | 1 | 1 | 1 | 4 | 0 | 0 | 0 | 1 | 1.54 |
| 22 | Doyle Road @ Hokanson Road area | MAH-004 | 2 | 4 | 0 | 1 | 3 | 4 | 0 | 0 | 4 | 0 | 1.53 |
| 23 | Cameron Road east of Cele Road | CTW-004 | 4 | 2 | 0 | 1 | 0 | 2 | 3 | 0 | 0 | 3 | 1.49 |

**Table 3-11.**
**Preliminary Stream Crossing Problem Area Ranking (Continued)**

| Prelim Rank | Problem Area by Watershed | Crossing ID | Criteria Scoring: C1 Size of Waterway | C2 Number of Reported Road Closures | C3 Impacts to Emergency Access Under Existing Conditions | C4 Existing Facility Condition | C5 Severity of Existing Sediment Condition | C6 Ratio of Drainage Area to Structure Opening Area | C7 Threat to Adjacent Upstream Habitable Structures | C8 Severity of Existing Debris Condition | C9 Could Improvement Project Be Combined With Roadway Project? | C10 Severity of Existing Erosion Condition | Total Score Based on Weighted Criteria |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | Ledgestone Terrace @ Trib to Pen Creek | SLA-007 | 1 | 0 | 4 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 1.48 |
| 25 | Albert Voelker Road @ Dry Creek | DRY-003 | 4 | 2 | 1 | 1 | 0 | 4 | 0 | 0 | 0 | 4 | 1.46 |
| 26 | Bitting School Road @ Willbarger Creek | WLB-012 | 4 | 4 | 1 | 1 | 1 | 4 | 0 | 0 | 0 | 0 | 1.45 |
| 27 | Springdale Road @ Walnut Creek | WLN-001 | 4 | 0 | 1 | 1 | 0 | 4 | 3 | 0 | 0 | 1 | 1.40 |
| 28 | D Morgan Road @ Trib to Grape Creek | BAR-002 | 3 | 0 | 4 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 1.38 |
| 29 | Westlake Drive near Woodcutters way | WDT-001 | 1 | 4 | 1 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 1.35 |
| 30 | Lime Creek Road | LKT-010 | 2 | 4 | 1 | 1 | 3 | 2 | 0 | 1 | 0 | 0 | 1.34 |
| 31 | Evelyn Road @ Maha Creek | MAH-002 | 4 | 4 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 1 | 1.34 |
| 32 | Crystal Bend Drive @ Harris Branch | HRS-001 | 4 | 0 | 0 | 1 | 0 | 4 | 4 | 1 | 0 | 0 | 1.34 |
| 33 | Peterson Road @ Hwy 812 | MAH-007 | 1 | 2 | 3 | 1 | 1 | 2 | 0 | 1 | 0 | 0 | 1.33 |
| 34 | Crumley Ranch Road @ Trib to Barton Creek | BAR-001 | 4 | 0 | 4 | 1 | 1 | 2 | 0 | 0 | 0 | 1 | 1.33 |
| 35 | Cottonwood Drive | LKT-003 | 4 | 0 | 4 | 0 | 0 | 4 | 0 | 1 | 0 | 0 | 1.33 |
| 36 | Littig Road @ Dry Creek | DRY-004 | 4 | 2 | 1 | 1 | 3 | 4 | 0 | 0 | 0 | 1 | 1.31 |
| 37 | Turnersville Road @ Maha Creek | MAH-001 | 2 | 2 | 1 | 1 | 4 | 4 | 0 | 1 | 0 | 0 | 1.27 |
| 38 | Weir Loop @ Williamson Creek | WMS-001 | 1 | 0 | 4 | 1 | 1 | 2 | 0 | 0 | 0 | 1 | 1.27 |
| 39 | Wild Basin Street | BEE-001 | 2 | 0 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 1.23 |
| 40 | Nameless Road near Shady Mountain | LKT-007 | 1 | 0 | 1 | 4 | 0 | 4 | 0 | 0 | 0 | 0 | 1.08 |
| 41 | WeirLpCir-SlaughterCreekTrib | SLA-006 | 1 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1.04 |
| 42 | Brita Olson Road east of Axell Ln | CTW-007 | 4 | 0 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 1 | 1.03 |
| 43 | Live Oak Drive | LKT-002 | 3 | 0 | 1 | 3 | 0 | 4 | 0 | 0 | 0 | 0 | 1.01 |
| 44 | Springdale Road @ Trib to Walnut Creek | WLN-002 | 3 | 0 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 0.92 |
| 45 | Pitter Pat Lane @ Williamson Creek | WMS-002 | 1 | 0 | 1 | 1 | 0 | 2 | 2 | 0 | 0 | 0 | 0.88 |
| 46 | Jones Road @ Willbarger Creek | WLB-011 | 4 | 0 | 1 | 0 | 1 | 4 | 0 | 0 | 0 | 1 | 0.81 |
| 47 | Reed Park Road | LKT-011 | 4 | 0 | 1 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0.80 |
| 48 | Klaus Lane @ Hwy 290 | DRY-002 | 2 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 0.65 |
| 49 | Paleface Ranch Road at Cox Road | PDT-002 | 1 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 1 | 0.63 |

**Table 3-11.**
**Preliminary Stream Crossing Problem Area Ranking (Concluded)**

| Prelim Rank | Problem Area by Watershed | Crossing ID | Criteria Scoring: C1 Size of Waterway | C2 Number of Reported Road Closures | C3 Impacts to Emergency Access Under Existing Conditions | C4 Existing Facility Condition | C5 Severity of Existing Sediment Condition | C6 Ratio of Drainage Area to Structure Opening Area | C7 Threat to Adjacent Upstream Habitable Structures | C8 Severity of Existing Debris Condition | C9 Could Improvement Project Be Combined With Roadway Project? | C10 Severity of Existing Erosion Condition | Total Score Based on Weighted Criteria |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 50 | Lund Carlson Road | DRY-001 | 1 | 2 | 0 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0.60 |
| 51 | Nameless Road near Linderman Lane | LKT-008 | 4 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0.60 |
| 52 | Wells Trace near Nez Perce Trace | DKR-001 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.54 |
| 53 | Paleface Ranch Road south of Cox Road | PDT-001 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0.52 |
| 54 | Bee Creek Road near Larkhall Drive | LKT-012 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0.47 |
| 55 | Williamson Road Northwest of Elm Grove Road | COW-001 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0.38 |
| 56 | Williamson Road Southeast of Elm Grove Road | COW-002 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0.36 |
| 57 | Brita Olson Road west of Axell Ln | CTW-005 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0.34 |
| 57 | Sandeen Road @ Manda Carlson Road | WLW-001 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.32 |
| 58 | Bois D'Arc Road | CTW-006 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.20 |

### *3.4 Preliminary Subdivision Drainage Evaluation Criteria*

Each subdivision problem area was evaluated against four criteria. Three of the four evaluation criteria involved qualitative indicators of the severity of various drainage problems that may exist in each area, similar to the stream crossing evaluation criteria. A fourth criterion considered the amount of capital already spent by the County on previous improvement projects within the area. The criteria were selected based on discussion with County staff and experience with previous studies. Table 3-12 lists the evaluation criteria.

***Table 3-12.***
***Evaluation Criteria***

| ID. | Description |
|---|---|
| C1. | Frequency of Reported Road Closures |
| C2. | Level of Flooding Observed and Documented by County Staff or Consultant |
| C3. | Extent of Existing Storm Drain System |
| C4. | Recent Improvements by County (including buy-outs) |

#### *3.4.1 Criteria Weighting*

As with the stream crossing criteria, the four criteria listed in Table 3-12 were assigned weights according to their relative importance in assessing problems at subdivision areas through a pair-wise comparison process. Table 3-13 lists the final criteria weights.

***Table 3-13.***
***Preliminary Evaluation Criteria Weights***

| ID. | Description | Weight | Criterion Rank |
|---|---|---|---|
| C2. | Level of Flooding Observed and Documented by County Staff or Consultant | 0.40 | 1 |
| C1. | Frequency of Reported Road Closures | 0.30 | 2 |
| C3. | Extent of Existing Storm Drain System | 0.20 | 3 |
| C4. | Recent Improvements by County (including buy-outs) | 0.10 | 4 |

As shown in Table 3-13, the criteria receiving the highest weights are again directly related to public safety. Level of Flooding Observed and Documented by County Staff or Consultant includes impacts to emergency access and threat of flooding to habitable structures.

The criterion receiving the lowest weight was the level of recent improvements completed by the County, as recent improvements may not have fully mitigated existing flood problems.

### *3.4.2 Subdivision Area Scoring*

Each subdivision area on the preliminary list was scored on a scale of 0 to 4 for each criterion. The basis of the scoring for each criterion is described in the following sections. Scoring for each subdivision area was based on the data collected as described in the subsequent section.

#### *3.4.2.1 Frequency of Reported Road Closures*

Scoring the frequency of road closures criterion was the same as for the stream crossings. Table 3-14 lists the scores associated with the number of road closures occurring within a particular subdivision area since June, 2000.

***Table 3-14.***
***Scoring for Criterion C1- Frequency of Reported Road Closures***

| Score | Number of Road Closures Since June, 2000 |
|---|---|
| 0 | 0 closures |
| 1 | |
| 2 | 1 closure |
| 3 | |
| 4 | more than 1 closure |

#### *3.4.2.2 Level of Flooding Observed and Documented by County Staff or Consultant*

The criterion concerning the level of flooding observed and documented by County and Consultant staff is a direct assessment of the extent of flooding that has occurred within particular subdivision areas during significant storm events. Accounts of observed flooding were obtained from County maintenance staff in the form of written reports, photographs, and verbal accounts. Significant flooding was also observed and documented by HDR staff during the field reconnaissance phase of this study as record rainfall amounts occurred throughout 2007, as described in the subsequent Data Collection section. The basis for scoring this criterion is listed in Table 3-15.

#### *3.4.2.3 Extent of Existing Storm Drain System*

The extent of existing storm drain system criterion assesses the level of storm drain system that exists within each subdivision area. The drainage infrastructure for each subdivision area was reviewed for sufficiently sized roadside ditches, driveway and cross culverts, and conveyance channels, or curb and gutter, curb inlets, and storm drain piping. The basis for scoring this criterion is listed in Table 3-16.

***Table 3-15.***
***Scoring for Criterion C2 - Level of Flooding Observed and Documented***

| *Score* | *Level of Flooding Observed & Documented* |
|---|---|
| 0 | No flooding of roadway or beyond right-of-way or easements |
| 1 | Moderate flooding witnessed with low risk to public safety or property (partial flooding of roads, or moderate flooding on private property) |
| 2 | No observations available |
| 3 | Significant flooding witnessed with moderate risk to public safety or property (significant water over road, or significant flooding on private property) |
| 4 | Severe flooding witnessed with high risk to public safety or property (vehicle access cut off, or flood water over lowest finished floor elevation of habitable structures) |

***Table 3-16.***
***Scoring for Criterion C3- Extent of Existing Storm Drain System***

| *Score* | *Extent of Exist. Storm Drain System* |
|---|---|
| 0 | Enclosed storm drain system with curb and gutter and inlets. |
| 1 | Moderate drainage infrastructure, defined roadside ditches with driveway and cross culverts |
| 2 | |
| 3 | Lack of drainage infrastructure, some defined roadside ditches with driveway and cross culverts |
| 4 | No drainage infrastructure, no defined roadside ditches, driveway or cross culverts |

#### *3.4.2.4 Completion of Recent Drainage Improvements by the County*

This criterion assesses whether or not drainage improvements have recently been made by the County and to what extent for a particular subdivision area (Table 3-17). Problem areas that have already received a significant amount of funding and improvements would be expected to have improved conditions and would presumably be viewed as a lower priority for additional funding by the County. Information on previous drainage improvements projects was obtained from County staff and assessed during site visits.

***Table 3-17.***
***Scoring for Criterion C4 - Have Recent Drainage Improvements been Completed by the County?***

| *Score* | *Recent Drainage Improvements Completed by the County* |
|---|---|
| 0 | Significant drainage improvements have been installed or properties bought out within last 10 years |
| 1 | |
| 2 | Moderate drainage improvements have been made within last 10 years |
| 3 | |
| 4 | No drainage improvements have been made by the County within the last 10 years |

### *3.5 Preliminary Subdivision Area Ranking*

As with the stream crossing rankings, the total score for each subdivision area was computed as the sum of the products of the criteria scores and the criteria weights. Table 3-18 lists each crossing's score for each criterion as well as each crossing's total score. The highest total score a subdivision area could receive is a value of 4.0, indicating severe problems and a high prioritization for further study and improvement. Table 3-18 lists the subdivision areas ranked from highest total score to lowest, providing a prioritized list. The 12 highest scoring subdivision areas were included for hydrologic and hydraulic evaluation as part of this study.

***Table 3-18.***
***Preliminary Subdivision Problem Area Ranking***

| | Subdivision Problem Area | Subdivision Criteria Scoring | | | | |
|---|---|---|---|---|---|---|
| | | C1 Frequency of Reported Road Closures (since June, 2000) | C2 Level of Flooding Observed and Documented by County Staff or Consultant | C3 Extent of Existing Storm Drain System | C4 Recent Improvements by County (including buy-outs) | Total Score Based on Weighted Criteria |
| **Ranking** | **Criteria Weights** | **0.30** | **0.40** | **0.20** | **0.10** | |
| 1 | Arroyo Doble | 4 | 4 | 3 | 2 | 3.6 |
| 2 | Twin Creek Park | 2 | 4 | 3 | 2 | 3 |
| 3 | Pamela Heights Subdivision | 2 | 3 | 1 | 4 | 2.4 |
| 4 | Trails End Subdivision | 2 | 2 | 3 | 4 | 2.4 |
| 5 | Swiss Alpine Subdivision | 0 | 3 | 3 | 4 | 2.2 |
| 6 | Kings Village Subdivision (Gardenia Dr. area) | 0 | 3 | 3 | 4 | 2.2 |
| 7 | Southwest Territory | 0 | 4 | 1 | 3 | 2.1 |
| 8 | Austin Lake Estates | 0 | 3 | 3 | 2 | 2 |
| 9 | Thoroughbred Farms Subdivision (Citation Ave. area) | 0 | 3 | 4 | 0 | 2 |
| 10 | Cross Creek Subdivision | 0 | 2 | 4 | 4 | 2 |
| 11 | Quiet Oaks Lane area | 4 | 1 | 1 | 2 | 2 |
| 12 | Wire Road Area | 0 | 3 | 1 | 3 | 1.7 |
| 13 | Yucca Drive area | 0 | 3 | 1 | 2 | 1.6 |
| 14 | Rolling Meadows Subdivision | 2 | 1 | 1 | 2 | 1.4 |
| 15 | Kellam Road area | 0 | 2 | 1 | 4 | 1.4 |
| 16 | Polk Road Area | 0 | 2 | 1 | 2 | 1.2 |

# Section 4
# Hydrologic and Hydraulic Analyses

The Drainage Basin Study included an analysis of storm water runoff and flood conditions for identified problem areas within the study area. Flood hydrology models were developed for each major stream, incorporating the unique characteristics of each watershed (including land use, basin slope, channel characteristics, and existing reservoirs) to simulate runoff for specific storm events at each priority problem area. Stream hydraulic models were also developed for these stream segments, incorporating the channel and floodplain geometry derived from available aerial topographic maps, ground survey data obtained as part of this study, roughness characteristics of the channel banks and floodplain, and the numerous bridges and culverts that cross the streams and affect flood levels. The following sections describe the analysis methodologies used in performance of this study.

## 4.1 Flood Hydrology

Flood hydrology was developed for major and minor watersheds in the study area for the priority problem areas for the purpose of evaluating flood conditions, including the capacity of channels, bridges, culverts, streets, and storm sewers. For major watersheds, which are generally defined as those with drainage areas greater than 200 acres, flood hydrology was developed using rainfall-runoff computer models, as gaged streamflow data was not available to provide for any statistical analyses. For minor watersheds (less than 200 acres), flood hydrology was evaluated using more simplistic methods, such as the rational method.

For analysis of existing or proposed culverts and bridges at stream crossings, the effect on flows due to storage behind such drainage structures was ignored because the volume of storage was typically very small relative to the sizes of watersheds and volumes of runoff produced from the design storms. The following sections describe the methods and key elements involved in evaluating the flood hydrology for major and minor watersheds.

### 4.1.1 Major Watersheds

Flood hydrology was developed for the major watersheds in the study area where priority problem areas existed. Rainfall-runoff computer models were created using HEC-HMS to develop relationships of flood frequency. HEC-HMS is a computer model developed by the U.S.

Army Corps of Engineers Hydrologic Engineering Center that provides for a variety of methods to be used to compute a runoff hydrograph for a watershed.

#### *4.1.1.1 Rainfall-Runoff Models*

For evaluating flood flow frequency for major watersheds, rainfall-runoff models were developed to compute runoff hydrographs at various locations within each watershed. A rainfall-runoff model simulates the watershed response to precipitation. The HEC-Hydrologic Modeling System (HEC-HMS) was used to model the flood hydrology in each watershed where priority problem areas existed. The model simulates the rainfall-runoff process and computes runoff hydrographs, peak discharges, and cumulative runoff volumes. The HEC-HMS model has numerous options for generating and routing flood hydrographs. As recommended in Travis County's Standards[1] and the City of Austin Drainage Criteria Manual (DCM),[2] the Soil Conservation Service's (SCS) methodology[3] was deemed the most appropriate technique for generating flood hydrographs. Key data required by the HEC-HMS model include: watershed area; precipitation depths; runoff curve number; unit hydrograph and basin lag time; design storm characteristics; and channel and reservoir routing parameters.

The drainage basin areas were delineated and subdivided using the best available aerial topographic mapping. The 2-foot contour interval on the mapping provided useful information in determining the major watershed divides and sub-basin delineations.

In order to develop flood hydrographs for storm events with various return periods, rainfall depths corresponding to the 2-, 10-, 25-, and 100-year recurrence intervals were used in accordance with the DCM. The SCS type III rainfall distribution with a 24-hour storm duration was used in the HEC-HMS model to provide a temporal distribution of rainfall. Areal rainfall reduction factors were used in the hydrologic models to reduce the point rainfall depths where appropriate, as recommended. A point rainfall depth versus duration summary for Travis County is provided in Table 4-1.

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1 Travis County Standards for Construction of Streets and Drainage in Subdivisions, Chapter 82, Travis County, August 2003.
2 City of Austin Drainage Criteria Manual, September, 2007.
3 Soil Conservation Service (SCS), "National Engineering Handbook," Section 4 - Hydrology, 1974.

**Table 4-1.**
**Depth-Duration-Frequency Data for Travis County, Texas (from Austin DCM)**

| Duration (minutes) | Rainfall Depth (inches) | | | | | |
|---|---|---|---|---|---|---|
| | Storm Frequency | | | | | |
| | 2-Year | 5-Year | 10-Year | 25-Year | 50-Year | 100-Year |
| 5 | 0.48 | 0.62 | 0.71 | 0.84 | 0.94 | 1.05 |
| 15 | 0.98 | 1.26 | 1.47 | 1.76 | 2.01 | 2.29 |
| 30 | 1.32 | 1.71 | 1.98 | 2.36 | 2.68 | 3.04 |
| 60 | 1.72 | 2.28 | 2.68 | 3.28 | 3.79 | 4.37 |
| 120 | 2.16 | 2.89 | 3.42 | 4.20 | 4.88 | 5.66 |
| 180 | 2.32 | 3.13 | 3.71 | 4.55 | 5.28 | 6.11 |
| 360 | 2.67 | 3.56 | 4.21 | 5.14 | 5.94 | 6.85 |
| 720 | 3.06 | 4.07 | 4.81 | 5.90 | 6.86 | 7.96 |
| 1,440 | 3.44 | 4.99 | 6.10 | 7.64 | 8.87 | 10.20 |

#### 4.1.1.2.1 SCS Runoff Curve Number

The SCS runoff curve number procedure[4] is an accepted method for computing abstractions for storm rainfall. Abstractions are defined as the physical processes (such as soil infiltration and detention or retention by vegetation and/or other means) that effectively reduce the volume of precipitation that becomes runoff. The rainfall that is in excess of the abstractions and becomes runoff is referred to as the excess rainfall. Therefore, for a storm event as a whole, the excess rainfall is always less than or equal to the depth of precipitation. The SCS runoff curve number method relates soil types, antecedent soil moisture, and land use to precipitation abstractions. This method was used in conjunction with information from the Travis County Soil Survey,[5] available aerial topographic maps, and the County's standards to develop a runoff curve number for each sub-basin considered in the study. Curve numbers were developed for existing and fully developed or ultimate land use conditions. For the 2-year through 100-year flood events, average antecedent moisture conditions (AMC-II) were assumed.

[4] SCS, Op. Cit., 1971.
[5] SCS, "Soil Survey of Travis County, Texas," U.S. Dept. of Agriculture, May 1974.

#### *4.1.1.2.2 SCS Unit Hydrograph*

The unit hydrograph method is the component in the rainfall-runoff model that transforms the rainfall excess into a surface runoff hydrograph. Since the physical characteristics of a watershed (e.g., shape, size, slope, etc.) are generally constant, it is expected that considerable similarity in the shape of runoff hydrographs from storms of similar rainfall characteristics will result. The unit hydrograph for a watershed is defined as a direct runoff hydrograph resulting from one inch of excess rainfall generated uniformly over the drainage area at a constant rate for an effective duration.[6]

The SCS unit hydrograph method relates hydrograph characteristics to a physical characteristic of the watershed, the basin time to peak ($t_p$). The parameter $t_p$ is defined as the time from the beginning of the rainfall event to the time at which the peak runoff rate is observed at the watershed outlet. The time to peak of a basin can be estimated using the following empirical equation:

$$t_p = 0.6\ T_c$$

where:

$T_c$ = Time of concentration for the watershed.

The time of concentration is defined as the time it takes for a drop of rain that falls on the most hydraulically remote point in the watershed to contribute to the flow at the drainage basin outlet. Times of concentration for each sub-basin within the drainage basins were computed using available topographic mapping and the Kerby-Kirpich method.[7] The SCS unit hydrograph method was utilized in the HEC-HMS model for all major watersheds in the study.

#### *4.1.1.2.3 Channel Routing*

Routing of flood flows from the outlet of an upstream sub-basin to the next sub-basin outlet downstream was accomplished using the Modified Puls method in HEC-HMS.[8] The flow at the upstream end of a channel was routed to the downstream outlet using Normal Depth

[6] Chow, Ven Te, *et al*., "Applied Hydrology," McGraw-Hill Book Co., 1988.
[7] Roussel, Meghan C., D.B. Thompson, X. Fang, G. Cleveland, and C.A. Garcia, "Time-Parameter Estimation for Applicable Texas Watersheds," U.S. Geological Survey, Texas Water Science Center, Report No. 0-4696-2, Sponsored by Texas Department of Transportation, Research and Technology Implementation Office, Austin, TX, August, 2005..
[8] USACE, Op. Cit., September 1990.

Storage techniques. Cross-section geometry, slopes, and Manning's roughness coefficients were obtained from the County's aerial topographic mapping and used as input for the hydrologic model.

### *4.1.2 Minor Watersheds*

Flood hydrology was developed for minor watersheds in the study area. Minor watersheds are considered subbasins with drainage areas of less than 100 acres that exist within the major watersheds of the study areas. Minor watersheds are typically associated with a specific area with known drainage problems, such as flooding of homes and roadways due to overflow from inadequate storm drain systems, and/or flooding of minor channels. These were typically located within neighborhoods or subdivision areas within the County. Flood hydrology for minor watersheds was analyzed using the Rational Method, as outlined in the DCM. The Rational Method is an empirical runoff formula that has gained wide acceptance because of its simple intuitive treatment of peak storm runoff rates in areas less than 200 acres. This method relates runoff to rainfall intensity, surface area and surface characteristics by the formula:

$$Q = C\ I\ A$$

where:

- Q = Peak runoff rate, in cubic feet per second (cfs);
- C = Runoff coefficient;
- I = Average rainfall intensity, for a duration equal to the time of concentration, in inches per hour; and
- A = Drainage area to the point under consideration, in acres.

The runoff coefficient (C) accounts for abstractions for losses between rainfall and runoff, which may vary with time for a given drainage area. These losses are caused by interception by vegetation, infiltration into permeable soils, retention in surface depressions, and evaporation and transpiration. Runoff coefficients used in the study are presented in the DCM (referenced by the County's standards) for various types of areas. Rainfall intensity (I) is the average rate of rainfall in inches per hour. Intensity is selected on the basis of design frequency and rainfall duration. For the Rational Method, the critical rainfall intensity is the rainfall having a duration equal to the time of concentration of the drainage basin. Rainfall intensity curves are presented in the Drainage Criteria Manual. The Rational Method was applied to minor watersheds in the study to compute peak runoff rates to analyze the capacity of existing systems and to size proposed facilities.

## 4.2 Stream Hydraulics

Hydraulic models were developed for each of the major streams in the County at priority problem area locations for the purpose of assessing flood conditions, including water surface elevations, channel capacities, and hydraulic capacities of existing drainage structures. Peak runoff rates computed as part of the rainfall-runoff analysis (Section 4.1) were used in conjunction with available aerial topographic mapping[9] and survey data to develop the stream hydraulic models. Water surface profiles for each stream segment analyzed as part of the study were computed for the 2-, 10-, 25-, and 100-year return period flood events. The resulting existing floodplain areas were mapped for the 2-year and 100-year flood events using the survey data and aerial topographic maps as a base for floodplain delineation. The following sections describe the key elements involved in hydraulic modeling of the stream segments in the study area.

### 4.2.1 Selection of Stream Hydraulic Model

The USACE Hydrologic Engineering Center (HEC) developed the computer model HEC-RAS[10] for the computation of water surface profiles. This model was developed as part of the HEC's "Next Generation" (NexGen) of hydrologic engineering software. HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking, multi-user network environment. The system is comprised of a graphical user interface (GUI), separate hydraulic analysis components, data storage and management capabilities, graphics, and reporting facilities. The HEC-RAS software allows the user to perform one-dimensional steady flow calculations. HEC-RAS employs the standard step method and includes a variety of computation procedures for analyzing bridges, culverts, and other hydraulic structures that are encountered on most rivers and streams. The HEC-RAS model requires the following input data:

- Channel cross section geometry;
- Bridge/culvert geometry;

9 City of Austin, Op. Cit., September 2007.
10 USACE, Hydrologic Engineering Center , "HEC-RAS River Analysis System," User's Manual, Davis, California, July 1995.

- Flow lengths;
- Manning's roughness coefficient estimates; and
- Streamflow.

Channel cross-section geometry and flow lengths were obtained from available aerial topographic mapping and ground survey sections. Bridge and culvert geometry was obtained from a variety of sources, including the existing Federal Emergency Management Agency (FEMA) model and/or field measurements. Manning's roughness coefficients were selected based primarily on field observations and interpretations from aerial mapping. Streamflows used in the hydraulic models were the peak flows computed for the 2-year through 100-year flood events, obtained from the flood hydrology model (Section 4.1).

### 4.2.2 Existing FEMA Models

FEMA studies and mapping performed for Travis County were recently updated as part of the Travis County Map Modernization Program which was initiated in 2003 and made effective in 2008. The current stream hydraulic models from the FEMA studies were obtained and utilized, where applicable, as part of the analyses. Many of the stream segments in the Travis County Unincorporated Area, however, do not have stream hydraulic models available as the streams have not been studied in detail.

### 4.2.3 Channel Modifications

Channel modifications were evaluated for a number of the flood problem areas identified in this study. HEC-RAS offers a convenient method for analyzing a range of channel improvement options and includes computational procedures for estimating excavation volumes and computing revised flood levels with the channel improvements in place. Earthen and concrete channel improvements were considered at various locations as a part of this study. Recommended channel modifications were based on the guidelines provided in the County's Standards for Constructing Streets and Drainage in Subdivisions.[11]

## 4.3 Roadway / Street Drainage

Roadways and streets in the developed portions of the study area serve an important and necessary drainage service even though their primary function is for the movement of traffic.

Water will often tend to follow streets and roadways, therefore, the analysis of roadway drainage is an important part of the overall study in order to reduce drainage problems that occur due to excessive street flow. Roadway drainage was analyzed using standard methods based on the type of roadway and roadway drainage system. Most of the problem areas identified in the study have roadside ditches to convey storm water runoff and do not have curb and gutter or underground storm drain systems. Therefore, open channel flow calculations using Manning's equation were typically employed to evaluate the capacity of the roadway drainage systems.

### 4.4 Hydrologic and Hydraulic Analysis Results

The results of the hydrologic and hydraulic analysis of the high priority areas provided the quantitative data necessary to develop a final prioritized list of problem areas. The data was used to determine the frequency and depths of overtopping at stream crossing problem areas which allowed evaluation of impacts to emergency access and the potential threat of flooding to adjacent habitable structures. The analysis results also provided quantitative data needed to determine frequency and extent of minor watershed flooding within the high priority subdivision problem areas. Drainage area maps, hydrologic parameters, and computed discharges for each problem area within the studied watersheds are included in Appendix B. A summary of computed discharges and overtopping depths and WSELs for each stream crossing problem area is presented in Table 4-2. Computed discharges within subdivision problem areas are provided on their respective exhibits in Appendix B.

The existing conditions flooding exhibits in Appendix B provide a graphic representation of the existing conditions flood problems that were determined based on the results of the hydrologic and hydraulic analyses. The exhibits for each stream crossing show the limits of the computed 2-year and 100-year floodplains across each drainage structure as well as the computed 2-, 10-, 25-, and 100-year water surfaces in profile and cross section. A table is provided for each stream crossing that presents the computed WSEL and overtopping depths for each storm frequency. Exhibits for subdivision problem areas show the limits of computed100-year floodplains and estimated areas of shallow flooding, capacities of deficient drainage infrastructure, and general descriptions of problem areas. Habitable structures within floodplains

[11] City of Austin, Op. Cit., September 2007.

*Table 4-2.*
*Summary of Stream Crossing Discharges & Overtopping Depths*

| ***Problem Area by Watershed*** | ***Crossing ID*** | ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Developed Conditions Peak Discharge (cfs)*** | | | | ***Q2 Overtopping*** | | ***Q10 Overtopping*** | | ***Q25 Overtopping*** | | ***Q100 Overtopping*** | | ***Avg. Depth from Annual Peak Event (ft)*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***Depth (ft)*** | ***Elev. (ft)*** | ***Depth (ft)*** | ***Elev. (ft)*** | ***Depth (ft)*** | ***Elev. (ft)*** | ***Depth (ft)*** | ***Elev. (ft)*** | |
| **Criteria Weights** | | | | | | | | | | | | | | | | | | |
| Fall Creek Road @ Unnamed Trib to Fall Creek | FAL-001 | 903 | 2,326 | 3,197 | 4,662 | 913 | 2,357 | 3,241 | 4,729 | 2.31 | 820.42 | 3.54 | 821.40 | 4.09 | 821.76 | 4.99 | 822.78 | 1.4 |
| Great Divide Road @ Little Barton Creek | LBA-001 | 2,045 | 5,322 | 7,340 | 10,750 | 2,343 | 5,790 | 7,878 | 11,382 | 3.92 | 872.39 | 5.69 | 873.86 | 6.46 | 874.46 | 7.56 | 875.41 | 2.4 |
| Pedernales Canyon Trail @ Lick Creek | LCK-001 | 1,362 | 3,640 | 5,053 | 7,449 | 1,469 | 3,897 | 5,399 | 7,941 | 1.86 | 803.43 | 3.20 | 804.71 | 3.78 | 805.27 | 4.63 | 806.06 | 1.2 |
| Navarro Creek Rd @ Navarro Creek | DRE-006 | 586 | 1,448 | 1,969 | 2,843 | 741 | 1,666 | 2,210 | 3,112 | 0.86 | 443.33 | 1.46 | 443.85 | 1.71 | 444.13 | 2.08 | 444.45 | 0.6 |
| Tom Sassman Road @ Maha Creek | MAH-003 | 2,148 | 5,135 | 6,965 | 10,026 | 2,263 | 5,306 | 7,162 | 10,258 | 2.04 | 598.10 | 3.45 | 599.48 | 4.06 | 600.02 | 4.82 | 600.71 | 1.3 |
| Wyldwood Road @ Slaughter Creek* | SLA-004 | 3,000** | 5,700 | 9,000** | 17,160 | n/a | n/a | n/a | n/a | 6.18 | 749.26 | 8.31 | 751.17 | 10.17 | 752.69 | 13.08 | 754.54 | 3.7 |
| Felder Lane @ Cottonwood Creek | CTW-003 | 878 | 1,920 | 2,527 | 3,532 | 937 | 2,030 | 2,666 | 3,718 | 2.09 | 537.17 | 3.01 | 537.96 | 3.29 | 538.13 | 3.75 | 538.53 | 1.3 |
| Jesse Bohls Rd. @ unnamed trib to Willbarger Creek | WLB-002 | 2,360 | 5,399 | 7,206 | 10,217 | 2,859 | 6,045 | 7,900 | 10,969 | 1.82 | 578.22 | 4.34 | 580.74 | 4.90 | 581.30 | 5.60 | 582.00 | 1.4 |
| Big Sandy Dr @ Long Hollow Creek | LKT-005 | 2,746 | 7,173 | 9,923 | 14,593 | 2,915 | 7,405 | 10,172 | 14,857 | 3.76 | 896.99 | 6.01 | 899.12 | 7.02 | 900.05 | 8.37 | 901.29 | 2.8 |
| Linden Road @ Maha Creek | MAH-009 | 1,878 | 5,452 | 7,781 | 11,953 | 2,114 | 5,893 | 8,304 | 12,573 | 2.39 | 514.74 | 3.92 | 516.24 | 4.60 | 516.87 | 5.58 | 517.88 | 1.5 |
| Tumbleweed Trail @ unnamed trib to Lake Austin | LKA-001 | 281 | 722 | 991 | 1,443 | 332 | 811 | 1,098 | 1,577 | 1.36 | 726.57 | 2.35 | 727.53 | 2.77 | 727.93 | 3.34 | 728.46 | 0.9 |
| Nameless Road @ unnamed trib to Big Sandy | LKT-006 | 472 | 1,155 | 1,566 | 2,254 | 508 | 1,228 | 1,660 | 2,380 | 1.06 | 863.19 | 1.83 | 863.87 | 2.18 | 864.18 | 2.68 | 864.63 | 0.7 |
| Gregg Lane @ Willbarger Creek | WLB-004 | 2,331 | 7,410 | 10,028 | 14,659 | 3,694 | 8,339 | 11,043 | 15,776 | 2.67 | 528.66 | 5.17 | 531.02 | 6.28 | 532.13 | 7.93 | 533.68 | 1.9 |
| Juniper Trail @ Long Hollow | LKT-004 | 2,407 | 6,139 | 8,423 | 12,276 | 2,565 | 6,360 | 8,664 | 12,534 | 5.25 | 954.02 | 7.81 | 956.21 | 8.93 | 957.12 | 11.21 | 959.20 | 3.9 |
| Jacobson Road @ Maha Creek | MAH-008 | 1,919 | 5,562 | 7,901 | 12,057 | 2,159 | 6,009 | 8,428 | 12,678 | 0.96 | 528.46 | 2.31 | 529.81 | 2.91 | 530.41 | 3.82 | 531.32 | 0.7 |
| Round Mountain Rd near Big Sandy Dr | LKT-013 | 3,147 | 9,124 | 13,237 | 20,127 | 3,407 | 9,542 | 13,716 | 20,674 | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0 |
| Bee Creek Road @ Bee Creek | WBC-001 | 2,492 | 6,916 | 9,765 | 14,720 | 2,818 | 7,449 | 10,386 | 15,478 | 4.73 | 699.83 | 7.86 | 702.03 | 9.28 | 702.71 | 11.27 | 704.22 | 3.1 |
| Nameless Road @ unnamed trib to Big Sandy | LKT-001 | 458 | 1,101 | 1,486 | 2,128 | 478 | 1,143 | 1,541 | 2,203 | 1.42 | 958.70 | 2.42 | 959.72 | 2.95 | 960.22 | 3.64 | 960.89 | 0.9 |
| Slaughter Creek Drive @ Trib to Slaughter Creek* | SLA-005 | 1,500** | 2,100 | 2,900** | 4,860 | n/a | n/a | n/a | n/a | 1.80 | 665.53 | 2.16 | 665.86 | 2.54 | 666.07 | 3.34 | 666.55 | 1.0 |
| Caldwell Ln @ River Timber Dr | COL-001 | 10 | 51 | 82 | 138 | 17 | 68 | 102 | 165 | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0 |
| Parsons Road @ Willbarger Creek | WLB-009 | 3,192 | 8,872 | 12,478 | 18,787 | 3,935 | 9,998 | 13,733 | 20,176 | 1.57 | 472.03 | 3.42 | 473.80 | 4.15 | 474.47 | 5.36 | 475.69 | 1.1 |
| Doyle Road @ Hokanson Road area | MAH-004 | 337 | 732 | 962 | 1,342 | 350 | 756 | 993 | 1,383 | 1.34 | 570.95 | 1.83 | 571.44 | 2.05 | 571.65 | 2.34 | 571.94 | 0.8 |
| Cameron Road east of Cele Road | CTW-004 | 1,306 | 2,915 | 3,862 | 5,433 | 1,463 | 3,149 | 4,132 | 5,757 | 0.57 | 546.36 | 2.49 | 548.24 | 3.13 | 548.86 | 4.00 | 549.68 | 0.6 |
| Ledgestone Terrace @ unnamed trib to Pen Creek | SLA-007 | 77 | 203 | 279 | 409 | 87 | 219 | 298 | 432 | 0.54 | 1010.90 | 0.96 | 1011.35 | 1.15 | 1011.53 | 1.41 | 1011.77 | 0.4 |
| Albert Voelker Road @ Dry Creek | DRY-003 | 2,420 | 5,521 | 7,509 | 10,742 | 2,738 | 5,959 | 7,993 | 11,284 | 0.99 | 452.52 | 3.41 | 454.94 | 3.39 | 454.92 | 3.96 | 455.49 | 0.9 |
| Bitting School Road @ unnamed trib to Willbarger Creek | WLB-012 | 187 | 22,579 | 32,089 | 48,369 | 262 | 23,866 | 33,623 | 50,929 | 1.19 | 420.28 | 5.34 | 425.60 | 6.21 | 426.38 | 7.28 | 427.36 | 1.3 |
| Springdale Road @ Walnut Creek* | WLN-001 | 12,000** | 15,250 | 19,000** | 28,460 | n/a | n/a | n/a | n/a | 5.12 | 525.62 | 6.36 | 526.83 | 7.58 | 528.02 | 10.51 | 530.93 | 3.6 |
| D Morgan Road @ Grape Creek | BAR-002 | 594 | 1,574 | 2,179 | 3,202 | 719 | 1,820 | 2,490 | 3,615 | 2.28 | 875.37 | 3.71 | 876.57 | 4.33 | 877.17 | 5.25 | 877.90 | 0.8 |
| Westlake Drive @ unnamed trib to Lake Austin | WDT-001 | 127 | 291 | 388 | 548 | 127 | 291 | 388 | 548 | 1.91 | 541.02 | 2.73 | 541.84 | 3.02 | 542.21 | 3.56 | 542.65 | 1.2 |
| Lime Creek Road @ Fisher Hollow | LKT-010 | 511 | 1,201 | 1,611 | 2,294 | 575 | 1,321 | 1,762 | 2,492 | 2.70 | 770.19 | 3.93 | 771.06 | 4.44 | 771.14 | 5.14 | 771.81 | 1.6 |
| Evelyn Road @ Maha Creek | MAH-002 | 1,880 | 4,664 | 6,314 | 9,050 | 1,996 | 4,859 | 6,554 | 9,355 | 0.00 | 603.44 | 1.41 | 606.62 | 2.24 | 607.40 | 3.27 | 608.36 | 0.3 |
| Crystal Bend Drive @ Harris Branch* | HRS-001 | 2,500** | 3,430 | 4,400** | 6,730 | n/a | n/a | n/a | n/a | 4.02 | 669.93 | 4.73 | 670.16 | 5.34 | 670.27 | 6.52 | 671.73 | 2.3 |
| Peterson Road @ Hwy 812 | MAH-007 | 135 | 305 | 405 | 570 | 141 | 314 | 415 | 583 | 0.18 | 551.16 | 0.34 | 551.34 | 0.41 | 551.40 | 0.50 | 551.49 | 0.1 |
| Crumley Ranch Road @ Trib to Barton Creek | BAR-001 | 2,157 | 5,743 | 7,965 | 11,730 | 2,426 | 6,196 | 8,502 | 12,384 | 0.00 | 944.81 | 3.79 | 953.26 | 5.01 | 954.48 | 6.66 | 956.13 | 0.6 |
| Cottonwood Drive @ Long Hollow | LKT-003 | 2,047 | 5,196 | 7,119 | 10,355 | 2,204 | 5,427 | 7,378 | 10,646 | 4.92 | 968.36 | 7.22 | 970.29 | 8.17 | 971.01 | 9.44 | 971.99 | 3.0 |
| Littig Road @ Dry Creek | DRY-004 | 2,474 | 5,808 | 7,850 | 11,172 | 2,796 | 6,257 | 8,347 | 11,727 | 0.79 | 434.30 | 2.88 | 436.34 | 4.11 | 437.52 | 4.96 | 438.40 | 0.8 |
| Turnersville Road @ Maha Creek | MAH-001 | 435 | 953 | 1,255 | 1,754 | 476 | 1,028 | 1,349 | 1,880 | 0.37 | 649.60 | 0.99 | 650.26 | 1.23 | 650.47 | 1.55 | 650.78 | 0.3 |
| Weir Loop @ Williamson Creek | WMS-001 | 77 | 185 | 249 | 357 | 89 | 206 | 275 | 390 | 0.30 | 1042.35 | 0.87 | 1042.89 | 1.06 | 1043.12 | 1.32 | 1043.35 | 0.3 |
| Wild Basin Ledge @ unnamed trib to Bee Creek | BEE-001 | 447 | 1,117 | 1,521 | 2,199 | 447 | 1,117 | 1,521 | 2,199 | 0.00 | 620.25 | 0.04 | 624.16 | 0.83 | 624.94 | 1.43 | 625.50 | 0.1 |
| Nameless Road @ Nameless Hollow | LKT-007 | 277 | 693 | 944 | 1,365 | 298 | 741 | 1,008 | 1,455 | 1.73 | 802.52 | 2.53 | 803.05 | 2.89 | 803.10 | 3.48 | 803.54 | 1.1 |
| Weir Loop Circle @ Devil's Pen Creek | SLA-006 | 254 | 662 | 913 | 1,335 | 275 | 719 | 991 | 1,450 | 0.61 | 1016.53 | 1.19 | 1017.09 | 1.41 | 1017.32 | 1.73 | 1017.66 | 0.4 |
| Brita Olson Road east of Axell Ln | CTW-007 | 1,745 | 3,908 | 5,184 | 7,305 | 1,808 | 4,024 | 5,329 | 7,496 | 0.00 | 503.38 | 0.00 | 506.23 | 3.47 | 509.83 | 3.91 | 510.27 | 0.2 |
| Live Oak Drive @ Sheep Hollow | LKT-002 | 584 | 1,506 | 2,072 | 3,022 | 614 | 1,568 | 2,151 | 3,130 | 1.97 | 974.30 | 2.98 | 975.26 | 3.40 | 975.65 | 3.96 | 976.16 | 1.2 |
| Springdale Road @ Trib 5 to Walnut Creek* | WLN-002 | 1,600** | 2,160 | 2,750** | 4,280 | n/a | n/a | n/a | n/a | 2.11 | 530.30 | 2.99 | 531.17 | 3.70 | 531.85 | 4.89 | 532.96 | 1.3 |
| Pitter Pat Lane @ Williamson Creek | WMS-002 | 263 | 651 | 886 | 1,277 | 294 | 708 | 956 | 1,369 | 0.86 | 993.40 | 1.56 | 994.08 | 1.86 | 994.33 | 2.26 | 994.79 | 0.6 |

or shallow flooding are also depicted by a red outline on both stream crossing and subdivision problem area exhibits. The exhibits in Appendix B are organized by study watershed.

# Section 5
# Final Problem Area Prioritization

## 5.1 Final Ranking Process

Each priority problem area was evaluated against specific criteria based on the results of the hydrologic and hydraulic analysis as described in the previous section. Similar to the preliminary ranking process, the criteria were weighted according to their relative importance in assessing the need to address issues at each problem area. Each problem area was then assigned a score for each criterion. The total score for each problem area was computed as the sum of the products of the criteria scores and the criteria weights. The problem areas were then ranked for inclusion in the next phase of the study, the Alternatives Analysis phase, on the basis of the total scores.

## 5.2 Final Stream Crossing Evaluation Criteria

Each stream crossing was evaluated against four criteria. Each of the four evaluation criteria measured severity of threat to public safety and welfare and risk to property damage based on quantitative data resulting from the hydrologic and hydraulic analysis. Table 5-1 lists the evaluation criteria.

***Table 5-1.***
***Stream Crossing Evaluation Criteria for Final Ranking***

| *ID.* | *Description* |
|---|---|
| C1. | Flooding of Upstream Habitable Structures |
| C2. | Road Overtopping Depth Relative to Minimum Depth for Emergency Access |
| C3. | Impacts to Emergency Access Routes During Flood Conditions |
| C4. | Average Overtopping Depth from Annual Peak Event |

### 5.2.1 Criteria Weighting

The four criteria listed in Table 5-1 were assigned weights according to their relative importance in assessing problems at the 45 high priority stream crossings. The final ranking criteria weights were established through the same pair-wise comparison process as that used for the preliminary ranking criteria weights. Table 5-2 lists the final criteria weights, with the criteria ranked in order from highest weight (most important) to lowest (least important).

***Table 5-2.***
***Evaluation Criteria Weights***

| *ID.* | *Description* | *Weight* | *Criterion Rank* |
|---|---|---|---|
| C3. | Impacts to Emergency Access Routes During Flood Conditions | 0.40 | 1 |
| C2. | Road Overtopping Depth Relative to Minimum Depth for Emergency Access | 0.30 | 2 |
| C1. | Flooding of Upstream Habitable Structures | 0.20 | 3 |
| C4. | Average Overtopping Depth from Annual Peak Event | 0.10 | 4 |

### *5.2.2 Stream Crossing Problem Area Scoring*

Each crossing on the preliminary list was scored on a scale of 0 to 4 for each criterion. Scoring for each of the 45 high priority stream crossings was based on the results of the hydrologic and hydraulic analysis as described in the subsequent section. A description of the scoring for each criterion is described in the following sections.

#### *5.2.2.1 Flooding of Upstream Habitable Structures*

The comparison of adjacent upstream habitable structure locations and elevations to computed 100-year WSELs is a direct assessment of the threat to structure flooding by minor and major watersheds at the high priority stream crossings. This criterion provides an assessment of areas in which improvements to crossings may reduce upstream habitable structure flooding by decreasing headwater elevations, and thus reduce backwater flood profiles at stream crossings. Conversely, it also identifies potential areas in which raising the road profile to add more structure capacity to reduce roadway overtopping frequency may result in an increase in habitable structure flooding due to increasing backwater flood profiles. The assessment made by this criterion is based on the hydrologic and hydraulic analysis described in the previous section and survey information obtained as part of the data collection phase of the study. Lowest floor elevations (LFEs) were surveyed for habitable structures that were identified during the preliminary ranking process as potentially being in the floodplain. Where LFEs were not obtained, structure LFEs were approximated from the best available topographic contour data. Table 5-3 lists the scoring for this criterion.

***Table 5-3.***
***Scoring for Criterion C1***
***Flooding of Upstream Habitable Structures***

| ***Score*** | ***Flooding of Upstream Habitable Structures*** |
|---|---|
| 0 | None |
| 1 | |
| 2 | LFE less than 1' below 100-yr floodplain |
| 3 | |
| 4 | LFE more than 1' below 100-yr floodplain |

Figure 5-1 shows an example of a habitable structure located within the floodplain limits and below the computed 100-year WSEL upstream of an undersized stream crossing.

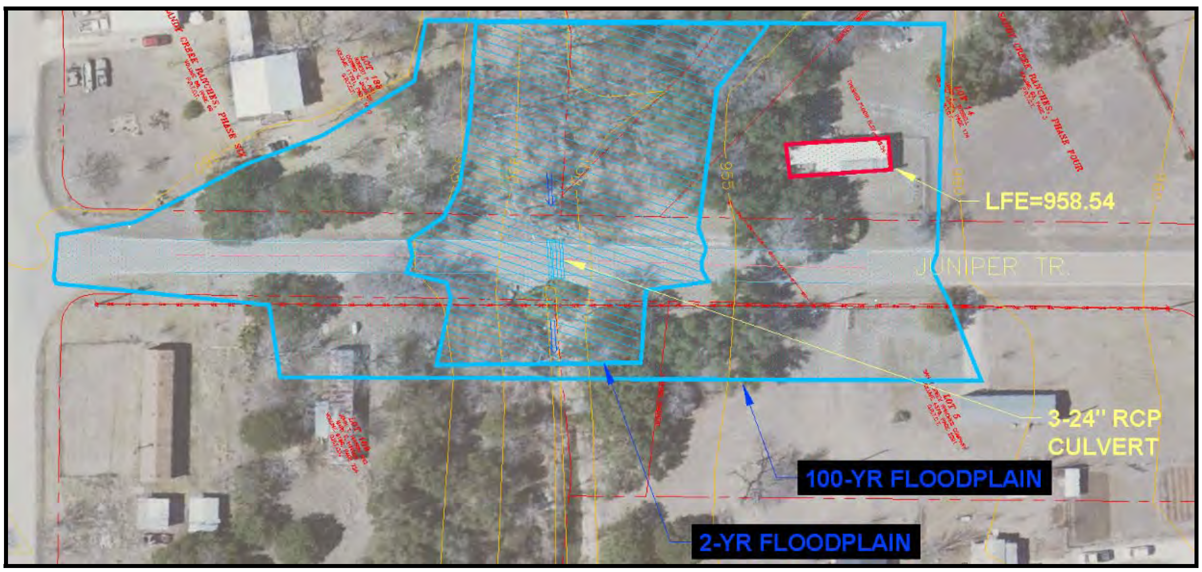



***Figure 5-1. Juniper Trail Low Water Crossing at Long Hollow***

### *5.2.2.2 Roadway Overtopping Depth relative to Emergency Access*

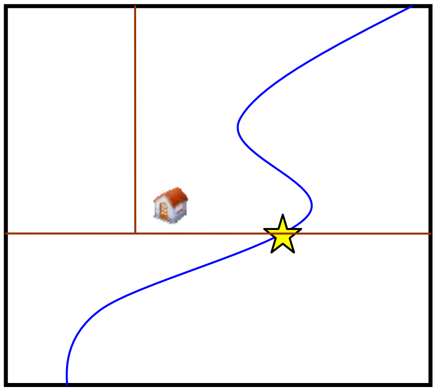
The roadway overtopping depth relative to emergency access criterion assesses whether or not a roadway is impassable by emergency vehicles due to roadway flooding during a given storm event. Based on the Drainage Criteria Manual, culverts and bridges should be sized to pass the 100-year storm event with less than 12" of overtopping for emergency access purposes. The results from the hydrologic and hydraulic analysis provided the basis for scoring this criterion. The computed overtopping depths for each design storm were presented in Table 4-2. The scoring for this criterion is listed in Table 5-4.

***Table 5-4.***
***Scoring for Criterion C2***
***Overtopping Depth vs.***
***Minimum for Emergency Access***

| *Score* | *Overtopping Depth vs. Min. for Emergency Access* |
|---|---|
| 0 | 100-yr overtopping less than 12" |
| 1 | |
| 2 | 100-yr overtopping greater than 12" |
| 3 | |
| 4 | 2-yr overtopping greater than 12" |

#### *5.2.2.3 Impacts to Emergency Access Routes During Flood Conditions*

The impacts to emergency access during flood conditions criterion is essentially the same criterion used in the preliminary ranking process. This criterion assesses the number of habitable structures to which access would be adversely impacted when access is restricted due to flooding at a particular crossing, as well as the number of alternative access routes that are available to the structures. The results from the hydrologic and hydraulic analysis were used to determine whether or not flooding from a 100-year storm, or more frequent storm event, restricted emergency access for each high priority stream crossing. Aerial photography was used to assess the location of structures relative to the crossings. The same assessment of access routes and habitable structures made for scoring this criterion during the preliminary ranking process were also used for criterion scoring for the final ranking. Figures 5-2a through 5-2e explain the basis for the assignment of scores for this criterion.



**Score: 0**

**Overtopping during 100-year storm event does not impede emergency access (overtopping depth is less than 12").**

**Legend**

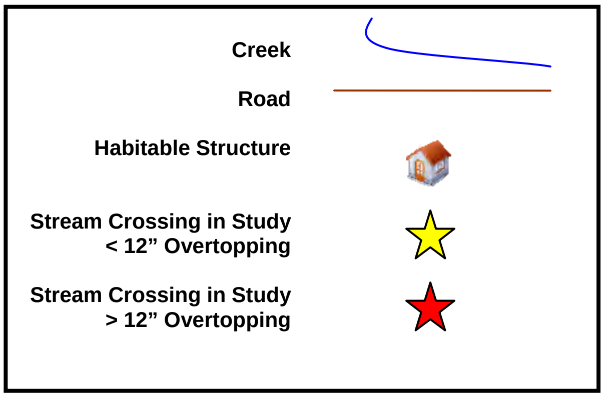
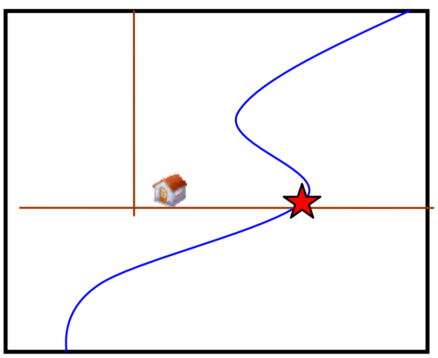


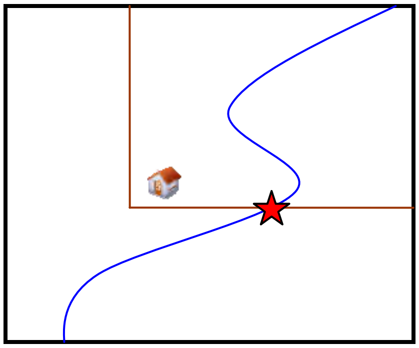

***Figure 5-2a. Impacts to Emergency Access during Flood Conditions - Score: 0***



**Score: 1**

**Multiple alternative access routes (to one or more habitable structures) exist which are not impacted by flooding.**

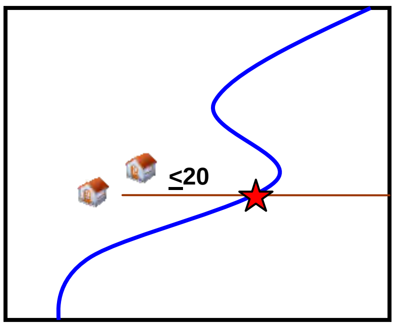
***Figure 5-2b Impacts to Emergency Access during Flood Conditions - Score: 1***



**Score: 2**

**One alternative access route (to one or more habitable structures) exists which is not impacted by flooding**

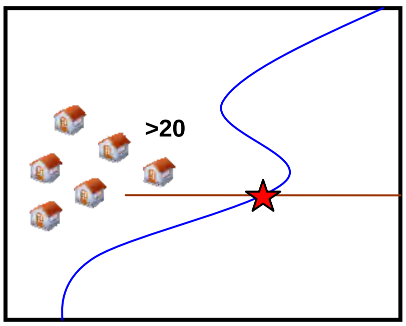
***Figure 5-2c. Impacts to Emergency Access during Flood Conditions - Score: 2***




**Score: 3**

**Complete access to twenty or less habitable structures is cut off by flooding.**

***Figure 5-2d Impacts to Emergency Access during Flood Conditions - Score: 3***




**Score: 4**

**Complete access to more than twenty habitable structure is cut off by flooding. No alternative access exists.**

***Figure 5-2e Impacts to Emergency Access during Flood Conditions - Score: 4***

#### *5.2.2.4 Average Overtopping Depth from Annual Peak Event*

The Average Overtopping Depth from Annual Peak Event criterion assesses the level of deficiency in drainage structure capacity and is effectively a measure of the relative level of danger to public welfare and safety that each stream crossing poses. The average overtopping depth represents the minimum depth of overtopping that could be expected to occur once a year on average for a given stream crossing. The deeper the average overtopping depth is, the greater the threat is to the traveling public. The average overtopping depth at each stream crossing is computed by adding up the computed overtopping depths, each weighted by their annual probability of occurrence, as represented by the equation below:

$$D_a = 0.5\ D_2 + 0.1\ D_{10} + 0.04\ D_{25} + 0.01\ D_{100}$$

Where $D_a$ is the average overtopping depth.

The results from the hydrologic and hydraulic analysis provided the basis for scoring this criterion. The computed average overtopping depth for each stream crossing was presented in Table 4-2. The scoring for this criterion is listed in Table 5-5.

***Table 5-5.***
***Scoring for Criterion C4 Average Overtopping Depth for Annual Peak Event***

| *Score* | *Average Overtopping Depth for Annual Peak Event (ft)* |
|---|---|
| 0 | < .5 |
| 1 | .6 to 1 |
| 2 | 1 .1 to 2 |
| 3 | 2.1 to 3 |
| 4 | > 3 |

### *5.2.3 Final Stream Crossing Ranking*

The total score for each crossing was computed as the sum of the products of the criteria scores and the criteria weights. Table 5-6 lists each stream crossing's score for each criterion as well as each crossing's total score. The highest total score a crossing could receive is a value of 4.0, indicating severe problems at the stream crossing and a high priority for improvements.

**Table 5-6.**
**Final Stream Crossing Problem Area Ranking**

| Final Rank | Problem Area | Crossing ID | Total Prelim Score Based on Weighted Criteria | Avg. Depth from Annual Peak Event | Habitable Structures LFE Below 100-yr WSEL Near & U/S of Xing | C1. Habitable Structure within 100-yr Backwater of Crossing | C2. Overtopping Depth vs. Minimum for Emergency Access | C3. Impacts to Emergency Access Routes under Existing Flood Conditions | C4. Severity of Overtopping | Total Final Score Based on Weighted Criteria |
|---|---|---|---|---|---|---|---|---|---|---|
| **Criteria Weights** | | | | | | **0.20** | **0.30** | **0.40** | **0.10** | |
| 1 | Big Sandy Dr @ Long Hollow Creek | LKT-005 | 1.97 | 2.8 | 1 | 2 | 4 | 4 | 3 | 3.50 |
| 2 | Springdale Road @ Walnut Creek | WLN-001 | 1.40 | 3.6 | 3 | 4 | 4 | 2 | 4 | 3.20 |
| 3 | Juniper Trail @ Long Hollow | LKT-004 | 1.16 | 3.9 | 1 | 2 | 4 | 4 | 4 | 3.60 |
| 4 | Wyldwood Road @ Slaughter Creek | SLA-004 | 2.10 | 3.7 | 0 | 0 | 4 | 4 | 4 | 3.20 |
| 5 | Great Divide Road @ Little Barton Creek | LBA-001 | 2.60 | 2.4 | 0 | 0 | 4 | 4 | 3 | 3.10 |
| 6 | Fall Creek Road @ Fall Creek | FAL-001 | 3.05 | 1.4 | 0 | 0 | 4 | 4 | 2 | 3.00 |
| 7 | Pedernales Canyon Trail @ Lick Creek | LCK-001 | 2.27 | 1.2 | 0 | 0 | 4 | 4 | 2 | 3.00 |
| 8 | Slaughter Creek Drive @ Trib 1 to Slaughter Creek | SLA-005 | 1.57 | 1.0 | 0 | 0 | 4 | 4 | 2 | 3.00 |
| 9 | Tumbleweed Trail @ unnamed trib to Lake Austin | LKA-001 | 1.93 | 0.9 | 0 | 0 | 4 | 4 | 1 | 2.90 |
| 10 | Crystal Bend Drive @ Harris Branch | HRS-001 | 1.34 | 2.3 | 7 | 4 | 4 | 1 | 3 | 2.70 |
| 11 | Cottonwood Drive @ Long Hollow | LKT-003 | 1.33 | 3.0 | 0 | 0 | 4 | 4 | 3 | 3.10 |
| 12 | Jacobson Road @ Maha Creek | MAH-008 | 1.73 | 0.7 | 5 | 4 | 2 | 4 | 0 | 3.00 |
| 13 | Linden Road @ Maha Creek | MAH-009 | 1.97 | 1.5 | 1 | 2 | 4 | 2 | 2 | 2.60 |
| 14 | Live Oak Drive @ Sheep Hollow | LKT-002 | 1.01 | 1.2 | 1 | 2 | 4 | 2 | 2 | 2.60 |
| 15 | Springdale Road @ Trib 5 to Walnut Creek | WLN-002 | 0.92 | 1.3 | 1 | 2 | 4 | 2 | 2 | 2.60 |
| 16 | Gregg Lane @ Wilbarger Creek | WLB-004 | 1.81 | 1.9 | 0 | 0 | 4 | 3 | 2 | 2.60 |
| 17 | Jesse Bohls Rd. @ unnamed trib to Wilbarger Creek | WLB-002 | 1.99 | 1.4 | 0 | 0 | 4 | 3 | 2 | 2.60 |
| 18 | Lime Creek Road @ Fisher Hollow | LKT-010 | 1.34 | 1.6 | 0 | 0 | 4 | 3 | 2 | 2.60 |
| 19 | Nameless Road @ unnamed trib to Big Sandy | LKT-001 | 1.62 | 0.9 | 0 | 0 | 4 | 3 | 1 | 2.50 |
| 20 | D Morgan Road @ Grape Creek | BAR-002 | 1.38 | 1.2 | 0 | 0 | 4 | 3 | 1 | 2.50 |
| 21 | Bee Creek Road @ Bee Creek | WBC-001 | 1.68 | 3.1 | 0 | 0 | 4 | 2 | 4 | 2.40 |
| 22 | Navarro Creek Rd @ Navarro Creek | DRE-006 | 2.25 | 0.6 | 0 | 0 | 2 | 4 | 1 | 2.30 |

**Table 5-6.**
**Final Stream Crossing Problem Area Ranking (Concluded)**

| Final Rank | Problem Area | Crossing ID | Total Prelim Score Based on Weighted Criteria | Avg. Depth from Annual Peak Event | Habitable Structures LFE Below 100-yr WSEL Near & U/S of Xing | C1. Habitable Structure within 100-yr Backwater of Crossing | C2. Overtopping Depth vs. Minimum for Emergency Access | C3. Impacts to Emergency Access Routes under Existing Flood Conditions | C4. Severity of Overtopping | Total Final Score Based on Weighted Criteria |
|---|---|---|---|---|---|---|---|---|---|---|
| 23 | Bitting School Road @ unnamed trib to Wilbarger Creek | WLB-012 | 1.45 | 1.3 | 0 | 0 | 4 | 2 | 3 | 2.30 |
| 24 | Weir Loop Circle @ Devel's Pen Creek | SLA-006 | 1.04 | 0.4 | 1 | 2 | 2 | 3 | 0 | 2.20 |
| 25 | Tom Sassman Road @ Maha Creek | MAH-003 | 2.11 | 1.3 | 0 | 0 | 4 | 2 | 2 | 2.20 |
| 26 | Felder Lane @ Cottonwood Creek | CTW-003 | 2.03 | 1.3 | 0 | 0 | 4 | 2 | 2 | 2.20 |
| 27 | Parsons Road @ Wilbarger Creek | WLB-009 | 1.54 | 1.1 | 0 | 0 | 4 | 2 | 2 | 2.20 |
| 28 | Westlake Drive @ unnamed trib to Lake Austin | WDT-001 | 1.35 | 1.2 | 0 | 0 | 4 | 2 | 2 | 2.20 |
| 29 | Nameless Road @ Nameless Hollow | LKT-007 | 1.08 | 1.1 | 0 | 0 | 4 | 2 | 2 | 2.20 |
| 30 | Ledgestone Terrace @ unnamed trib to Pen Creek | SLA-007 | 1.48 | 0.4 | 0 | 0 | 2 | 4 | 0 | 2.20 |
| 31 | Wild Basin Street @ unnamed trib to Bee Creek | BEE-001 | 1.23 | 0.1 | 0 | 0 | 2 | 4 | 0 | 2.20 |
| 32 | Caldwell Ln @ River Timber Dr | COL-001 | 1.55 | 0.0 | 0 | 0 | 2 | 4 | 0 | 2.20 |
| 33 | Nameless Road @ unnamed trib to Big Sandy | LKT-006 | 1.81 | 0.7 | 0 | 0 | 4 | 2 | 1 | 2.10 |
| 34 | Weir Loop @ Williamson Creek | WMS-001 | 1.27 | 0.3 | 0 | 0 | 2 | 4 | 0 | 2.20 |
| 35 | Doyle Road @ Hokanson Road area | MAH-004 | 1.53 | 0.8 | 0 | 0 | 4 | 1 | 1 | 1.70 |
| 36 | Crumley Ranch Road @ Trib to Barton Creek | BAR-001 | 1.33 | 0.6 | 0 | 0 | 2 | 2 | 1 | 1.50 |
| 37 | Albert Voelker Road @ Dry Creek | DRY-003 | 1.46 | 0.9 | 0 | 0 | 2 | 2 | 1 | 1.50 |
| 38 | Littig Road @ Dry Creek | DRY-004 | 1.31 | 0.8 | 0 | 0 | 2 | 2 | 1 | 1.50 |
| 39 | Pitter Pat Lane @ Williamson Creek | WMS-002 | 0.88 | 0.6 | 0 | 0 | 2 | 2 | 1 | 1.50 |
| 40 | Evelyn Road @ Maha Creek | MAH-002 | 1.34 | 0.3 | 0 | 0 | 2 | 2 | 0 | 1.40 |
| 41 | Turnersville Road @ Maha Creek | MAH-001 | 1.27 | 0.3 | 0 | 0 | 2 | 2 | 0 | 1.40 |
| 42 | Brita Olson Road east of Axell Ln | CTW-007 | 1.03 | 0.2 | 0 | 0 | 2 | 2 | 0 | 1.40 |
| 43 | Peterson Road @ Hwy 812 | MAH-007 | 1.33 | 0.1 | 0 | 0 | 0 | 3 | 0 | 1.20 |
| 44 | Cameron Road east of Cele Road | CTW-004 | 1.49 | 0.6 | 0 | 0 | 2 | 1 | 1 | 1.10 |
| 45 | Round Mountain Rd near Big Sandy Dr | LKT-013 | 1.70 | 0.0 | 0 | 0 | 0 | 2 | 0 | 0.80 |

## *5.3 Final Subdivision Flooding Evaluation Criteria*

Each subdivision problem area was evaluated against four criteria. Each of the four evaluation criteria measured severity of threat to public safety and welfare and risk to property damage based on quantitative data resulting from the hydrologic and hydraulic analysis. Table 5-7 lists the evaluation criteria.

***Table 5-7.***
***Subdivision Problem Area Evaluation Criteria for Final Ranking***

| ID. | Description |
|---|---|
| C1. | Flooding of Habitable Structures |
| C2. | Impact on Emergency Access |
| C3. | Level of Roadway Flooding |
| C4. | Inundation of Private Property |

### *5.3.1 Criteria Weighting*

As with the stream crossing criteria, the four criteria listed in Table 5-7 were assigned weights according to their relative importance in assessing problems at subdivision areas through a pair-wise comparison process. Table 5-8 lists the final criteria weights.

***Table 5-8.***
***Evaluation Criteria Weights***

| ID. | Description | Weight | Criterion Rank |
|---|---|---|---|
| C1. | Flooding of Habitable Structures | 0.40 | 1 |
| C2. | Impact on Emergency Access | 0.30 | 2 |
| C3. | Level of Roadway Flooding | 0.20 | 3 |
| C4. | Inundation of Private Property | 0.10 | 4 |

As shown in Table 5-8, the criteria receiving the highest weights are again directly related to public welfare and safety.

### *5.3.2 Subdivision Area Scoring*

Each high priority subdivision area was scored on a scale of 0 to 4 for each criterion. The basis of the scoring for each criterion is described in the following sections. Scoring for each subdivision area was based on the hydrologic and hydraulic analysis described in the subsequent section.

#### *5.3.2.1 Flooding of Habitable Structures*

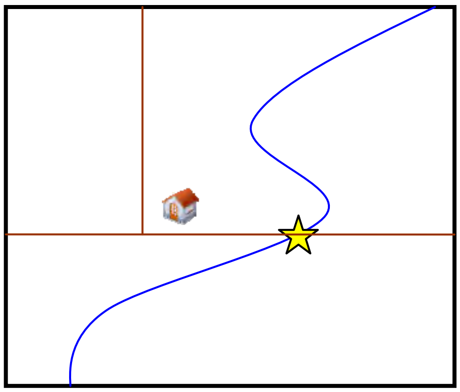
The comparison of habitable structure locations and LFE's to computed 100-year WSELs or estimated limits of shallow flooding is a direct assessment of the threat to structure flooding by minor and major watersheds at the high priority subdivision areas. This criterion provides an assessment of areas in which improvements to drainage infrastructure may reduce habitable structure flooding. The assessment made by this criterion is based on the hydrologic and hydraulic analysis described in the previous section and survey information obtained as part of the data collection phase of the study. Lowest floor elevations (LFEs) were surveyed for habitable structures that were identified during the preliminary ranking process as potentially being in the floodplain. Where LFEs were not obtained during the field survey, structure LFEs were approximated from the best available topographic contour data. Table 5-9 lists the scoring for this criterion.

***Table 5-9. Scoring for Criterion C1 Flooding of Habitable Structures***

| *Score* | *Flooding of Habitable Structures* |
|---|---|
| 0 | 0 habitable structures impacted |
| 1 | > 0 habitable structures potentially impacted by shallow flooding |
| 2 | > 10 habitable structures potentially impacted by shallow flooding |
| 3 | > 0 habitable structures located in the 100-year floodplain |
| 4 | > 10 habitable structures located in the 100-year floodplain |

#### *5.3.2.2 Impact on Emergency Access*

The impact to emergency access during flood conditions criterion is essentially the same criterion used in the stream crossing ranking process. This criterion assesses the number of habitable structures within a subdivision area to which access would be impacted when access is restricted due to flooding, as well as the number of alternative access routes that exist to the structures. Aerial photography was used to assess the location of structures relative to the flood prone areas. The results from the hydrologic and hydraulic analysis were used to determine whether or not flooding from a 100-year storm, or more frequent storm event, restricted emergency access within high priority subdivision areas. Figures 5-3a through 5-3c explain the basis for the assignment of scores for this criterion.



**Score: 0**

**Flooding does not impede emergency access (flooding depths are less than 12”).**

**Legend**

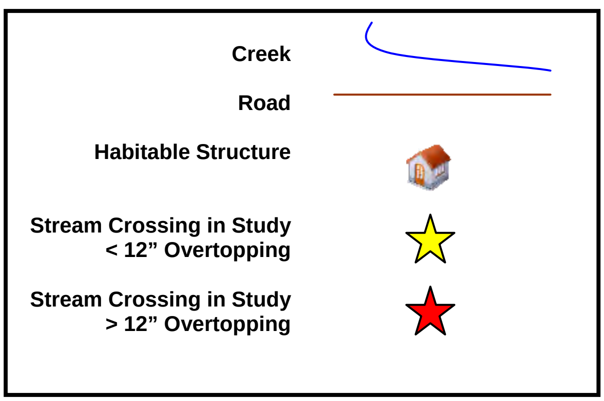
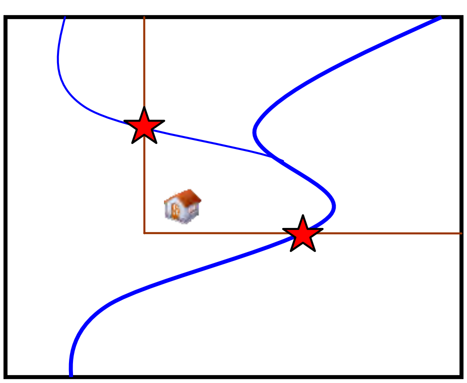


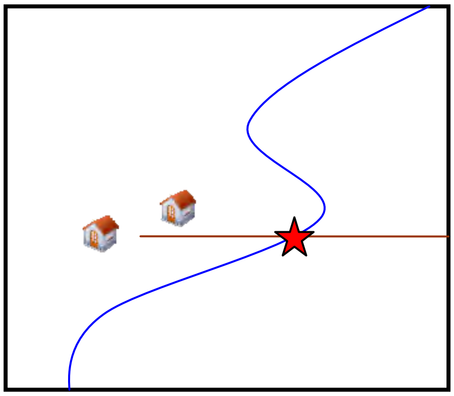

***Figure 5-3a. Impacts to Emergency Access during Flood Conditions - Score: 0***



**Score: 2**

**Complete access to one habitable structure is cut off by flooding.**

***Figure 5-3b Impacts to Emergency Access during Flood Conditions - Score: 2***



**Score: 4**

**Complete access to more than one habitable structure is cut off by flooding. No alternative access exists.**

***Figure 5-3c Impacts to Emergency Access during Flood Conditions - Score: 4***

### *5.3.2.3 Level of Roadway Flooding*

The Level of Roadway Flooding criterion assesses the level of inundation within the County right-of-way from minor watersheds. Excessive inundation or ponding of roadways can restrict access, cause automobile hydroplaning, cause damage to the roadway pavement structure, and can be a general nuisance to property owners and County maintenance staff. The basis for scoring this criterion is listed in Table 5-10.

***Table 5-10.***
***Scoring for Criterion C3 Level of Roadway Flooding***

| *Score* | *Level of Roadway Flooding* |
|---|---|
| 0 | None |
| 1 | |
| 2 | Moderate |
| 3 | |
| 4 | Severe |

### *5.3.2.4 Inundation of Private Property*

This criterion assesses the level of private property inundation (land only, not structures) that occurs in the form of both shallow flooding from minor watersheds and floodplain inundation from major watersheds. The results from the hydrologic and hydraulic analysis were used to determine the level of floodplain inundation of private property from larger streams and channels and the extent of shallow flooding within the high priority subdivision areas. The basis for scoring this criterion is listed in Table 5-11.

**Table 5-11.**
**Scoring for Criterion C4 Inundation of Private Property**

| Score | Inundation of Private Property |
|---|---|
| 0 | None |
| 1 | |
| 2 | Moderate |
| 3 | |
| 4 | Severe |

## 5.4 Final Subdivision Area Ranking

As with the stream crossing rankings, the total score for each subdivision area was computed as the sum of the products of the criteria scores and the criteria weights. Table 5-12 lists each crossing's score for each criterion as well as each crossing's total score. The highest total score a subdivision area could receive is a value of 4.0, indicating severe problems and a high prioritization for improvements. Table 5-12 lists the high priority subdivision areas ranked from highest total score to lowest, providing a final prioritized list.

**Table 5-12.**
**Final Subdivision Problem Area Ranking**

| Final Ranking | Subdivision Problem Area | Watershed | C1. Flooding of habitable structures | C2. Impact on emergency access | C3. Level of roadway flooding | C4. Inundation of private property | Total Final Score Based on Weighted Criteria |
|---|---|---|---|---|---|---|---|
| | **Criteria Weights** | | **0.40** | **0.30** | **0.20** | **0.10** | |
| 1 | Swiss Alpine Village | Maha | 4 | 4 | 4 | 4 | 4 |
| 2 | Arroyo Doble | Onion | 2 | 4 | 4 | 4 | 3.2 |
| 3 | Twin Creek Park | Onion | 2 | 4 | 4 | 4 | 3.2 |
| 4 | Thoroughbred Farms | South Fork | 3 | 4 | 2 | 2 | 3 |
| 5 | Southwest Territory | Little Bear | 4 | 0 | 3 | 4 | 2.6 |
| 6 | Austin Lake Estates | Lake Austin | 1 | 4 | 2 | 2 | 2.2 |
| 7 | Wire Road Area | Lime | 0 | 4 | 2 | 2 | 1.8 |
| 8 | Trails End | Lime | 1 | 0 | 3 | 3 | 1.3 |
| 9 | Quiet Oaks Lane area | Lockwood | 1 | 0 | 2 | 4 | 1.2 |
| 10 | Pamela Heights | Walnut | 1 | 0 | 2 | 2 | 1 |
| 11 | Kings Village | Walnut | 0 | 0 | 3 | 2 | 0.8 |
| 12 | Cross Creek | Big Sandy | 0 | 0 | 2 | 2 | 0.6 |

### *5.5 Final Priority Problem Areas*

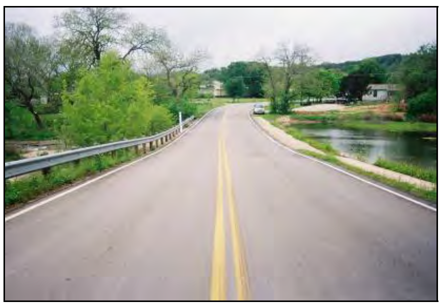
Forty priority problem areas were selected from the final ranked watershed problem areas for inclusion in the Alternatives Analysis phase of the study. The 40 problem areas include a combination of minor and major watershed stream crossings and subdivision problem areas. Based on discussions with the County, the 40 priority problem areas selected include the top 34 ranked stream crossing problem areas and the top 6 subdivision problem areas were selected. These areas are listed in Table 5-13 and the locations are shown on the County maps at the end of this section. The following sections provide a brief description of each of the top priority areas.

***Table 5-13.***
***Top 40 Priority Flood Problem Areas***

| ***Final Rank*** | ***Problem Area*** | ***Crossing ID*** |
|---|---|---|
| | ***Stream Crossings*** | |
| 1 | Big Sandy Dr @ Long Hollow | LKT-005 |
| 2 | Springdale Road @ Walnut Creek | WLN-001 |
| 3 | Juniper Trail @ Long Hollow | LKT-004 |
| 4 | Wyldwood Road @ Slaughter Creek | SLA-004 |
| 5 | Great Divide Road @ Little Barton Creek | LBA-001 |
| 6 | Fall Creek Road @ Unnamed Tributary to Fall Creek | FAL-001 |
| 7 | Pedernales Canyon Trail @ Lick Creek | LCK-001 |
| 8 | Slaughter Creek Drive @ Trib 1 to Slaughter Creek | SLA-005 |
| 9 | Tumbleweed Trail @ unnamed trib to Lake Austin | LKA-001 |
| 10 | Crystal Bend Drive @ Harris Branch | HRS-001 |
| 11 | Cottonwood Drive @ Long Hollow | LKT-003 |
| 12 | Jacobson Road @ Maha Creek | MAH-008 |
| 13 | Linden Road @ Maha Creek | MAH-009 |
| 14 | Live Oak Drive @ Sheep Hollow | LKT-002 |
| 15 | Springdale Road @ Trib 5 to Walnut Creek | WLN-002 |
| 16 | Gregg Lane @ Wilbarger Creek | WLB-004 |
| 17 | Jesse Bohls Rd. @ unnamed trib to Wilbarger Creek | WLB-002 |
| 18 | Lime Creek Road @ Fisher Hollow | LKT-010 |
| 19 | Nameless Road @ unnamed trib to Big Sandy | LKT-001 |
| 20 | D Morgan Road @ Trib to Grape Creek | BAR-002 |
| 21 | Bee Creek Road @ Bee Creek | WBC-001 |
| 22 | Navarro Creek Rd @ Navarro Creek | DRE-006 |
| 23 | Bitting School Road @ unnamed trib to Wilbarger Creek | WLB-012 |
| 24 | Weir Loop Circle @ Devil's Pen Creek | SLA-006 |
| 25 | Tom Sassman Road @ Maha Creek | MAH-003 |
| 26 | Felder Lane @ Cottonwood Creek | CTW-003 |
| 27 | Parsons Road @ Wilbarger Creek | WLB-009 |
| 28 | Westlake Drive @ unnamed trib to Lake Austin | WDT-001 |
| 29 | Nameless Road @ Nameless Hollow | LKT-007 |
| 30 | Ledgestone Terrace @ unnamed trib to Pen Creek | SLA-007 |
| 31 | Wild Basin Street @ unnamed trib to Bee Creek | BEE-001 |
| 32 | Caldwell Ln @ River Timber Dr | COL-001 |
| 33 | Nameless Road @ unnamed trib to Big Sandy | LKT-006 |
| 34 | Weir Loop @ Williamson Creek | WMS-001 |
| | ***Subdivision Areas*** | |
| 1 | Swiss Alpine | |
| 2 | Arroyo Doble | |
| 3 | Twin Creek Park | |
| 4 | Thoroughbred Farms | |
| 5 | Southwest Territory | |
| 6 | Austin Lake Estates | |

### *5.5.1 Big Sandy Drive at Long Hollow (LKT-005)*

Long Hollow is a large tributary to Big Sandy Creek in northwest Travis County with a watershed area of 1.8 square miles at the Big Sandy Drive crossing as shown on Figure 5-4. The Big Sandy Drive crossing is in the hill country area of northwest Travis County. The existing drainage structure consists of three 24" RCP with a concrete flow control structure on the upstream end as shown in the photos below. The flow control structure appears to be designed to provide a constant normal pool or pond upstream of the crossing given the location of the low level openings above existing grade.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,746 | 7,173 | 9,923 | 14,593 | 2,915 | 7,405 | 10,172 | 14,857 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 3.76 feet. Big Sandy Drive is also a single access way into a residential area including over 100 residences. At least one habitable structure LFE is below the computed 100-year floodplain directly upstream of the crossing. The drainage structure is in satisfactory condition with no significant erosion or sedimentation problems upstream or downstream of the crossing. The Big Sandy Drive crossing was ranked as the highest priority problem areas due to its frequency and depth of overtopping and the fact that it serves as the only access to over 100 residences. During even minor storm events, this crossing is impassable creating a significant public safety issue.

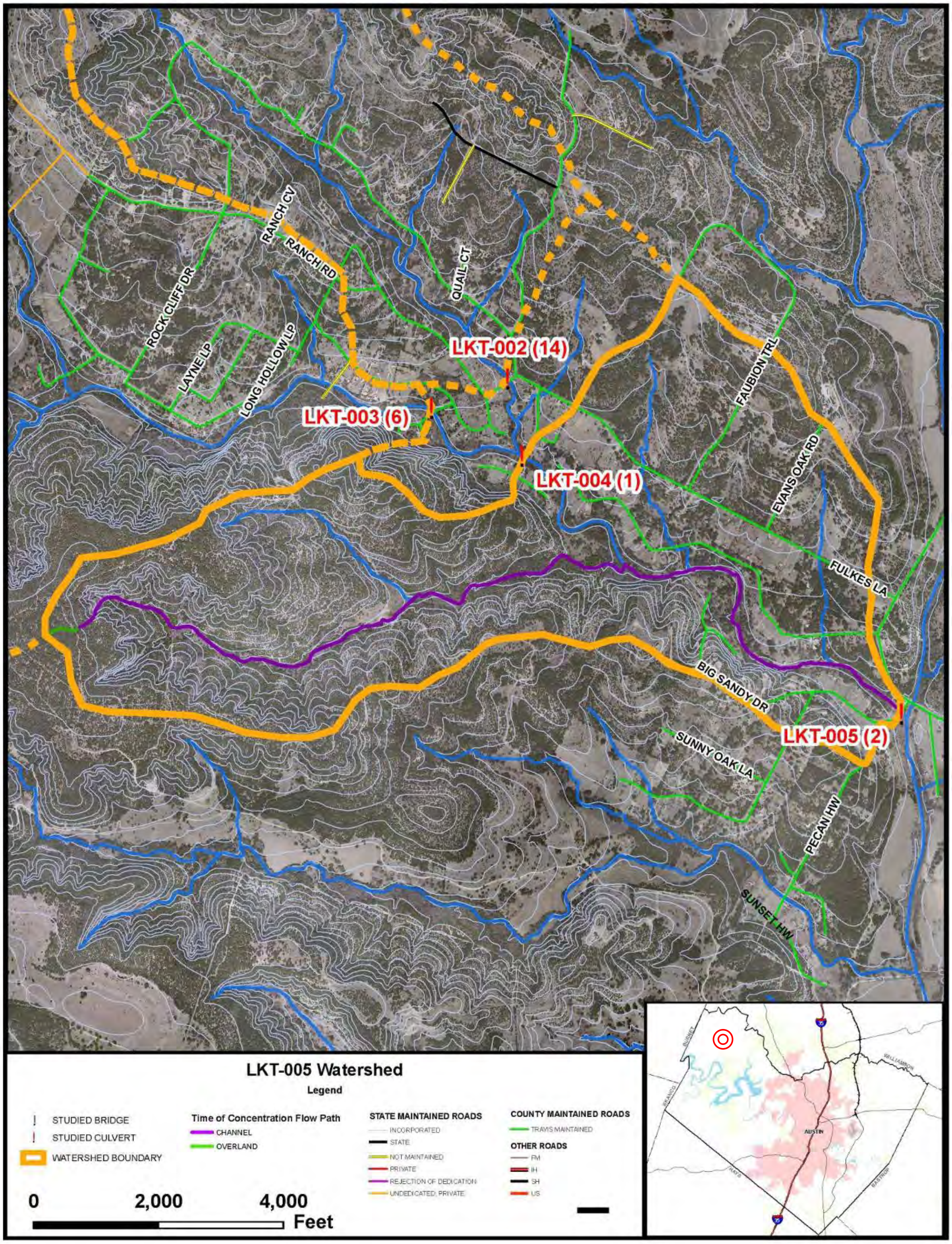



***Figure 5-4. Big Sandy Dr. @ Long Hollow Creek***

### *5.5.2 Springdale Road at Walnut Creek (WLN-001)*

Walnut Creek is a major waterway with a watershed area of approximately 29 square miles at the Springdale Road crossing in eastern Travis County as shown on Figure 5-5. The existing drainage structure is a three-span slab beam bridge as shown in the photos below. This crossing is included in the current effective FEMA FIS of Walnut Creek as a Zone AE SFHA. The headwaters of Walnut Creek lie in the developed area of the City of Austin. Rainfall runoff from this urban area contributes to flooding of this roadway crossing.

The following table provides a summary of discharges at the crossing from the effective FEMA FIS:

| ***Existing Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 12,000* | 15,250 | 19,000* | 28,460 |
| *Interpolated flow | | | |

The Springdale Road bridge is a relatively large structure in the County's system, however, the high peak runoff rates from the large urban watershed overwhelm this structure on a frequent basis. Based on the FEMA FIS data, this stream crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 5.12 feet. Springdale Road connects to US 290 and is one of two primary access routes into a residential neighborhood including over 100 residences. Approximately three habitable structures are located within the FEMA 100-year floodplain directly upstream of the crossing. Despite the frequent overtopping, the drainage structure is in good condition with minor erosion upstream and downstream of the crossing.

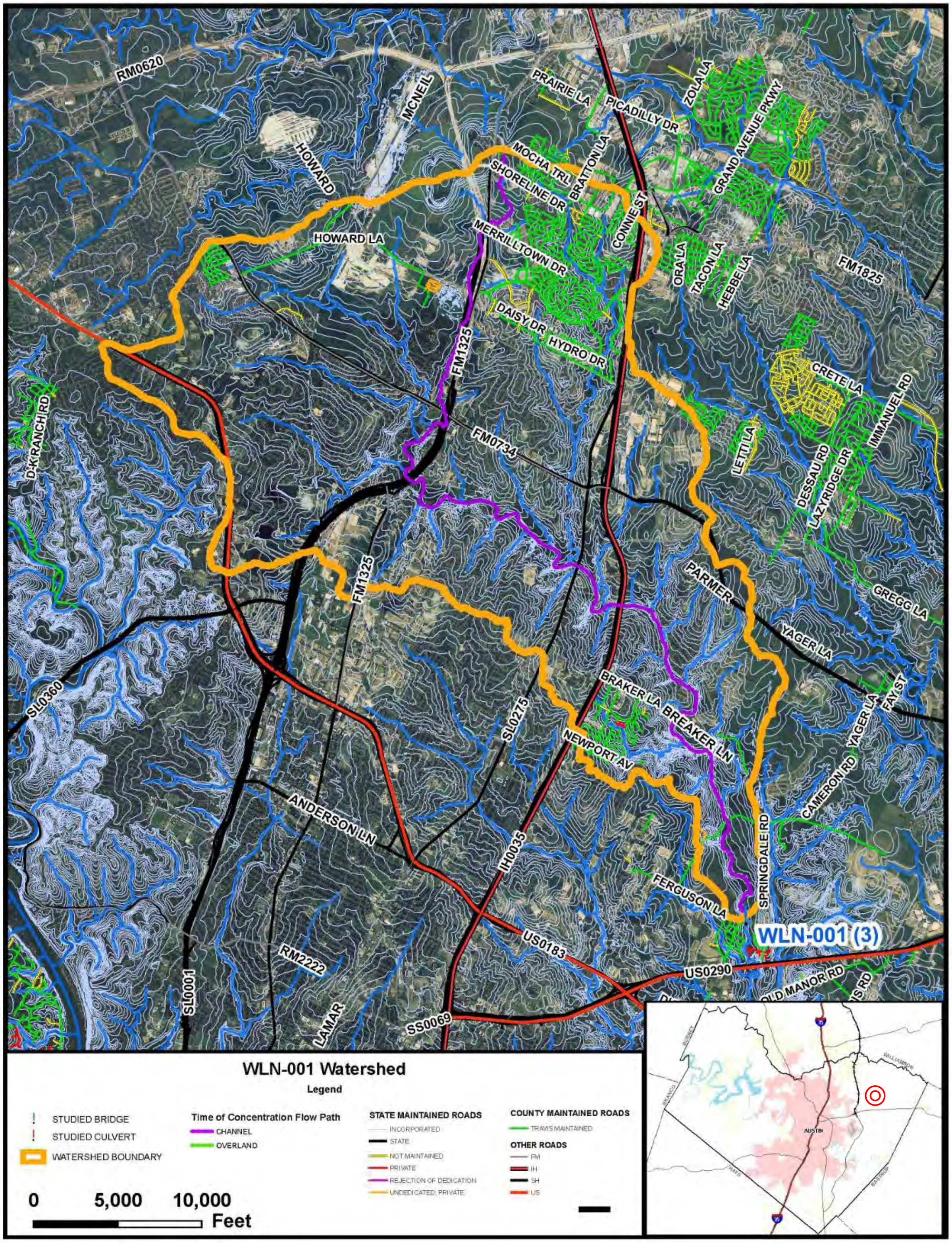



*Figure 5-5. Springdale Road @ Walnut Creek*

### *5.5.3 Juniper Trail at Long Hollow (LKT-004)*

Long Hollow is a large tributary to Big Sandy Creek with a watershed area of 5.705 square miles at the Juniper Trail crossing as shown on Figure 5-6. The Long Hollow is in the hill country area of northwest Travis County. The existing drainage structure is a typical low water crossing consisting of three shallow 24” RCP at the bottom of a steep sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Developed Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,407 | 6,139 | 8,423 | 12,276 | 2,565 | 6,360 | 8,664 | 12,534 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 5.25 feet. Juniper Trail is also a single access way into a residential area including approximately 17 residences. At least one habitable structure LFE is below the computed 100-year floodplain directly upstream of the crossing. The drainage structure is in fair condition with minor erosion on the downstream side of the crossing. Juniper Trail was ranked as one of the highest priority problem areas due to its frequency and depth of overtopping and the fact that it is often impassable as the only access to a residential area.

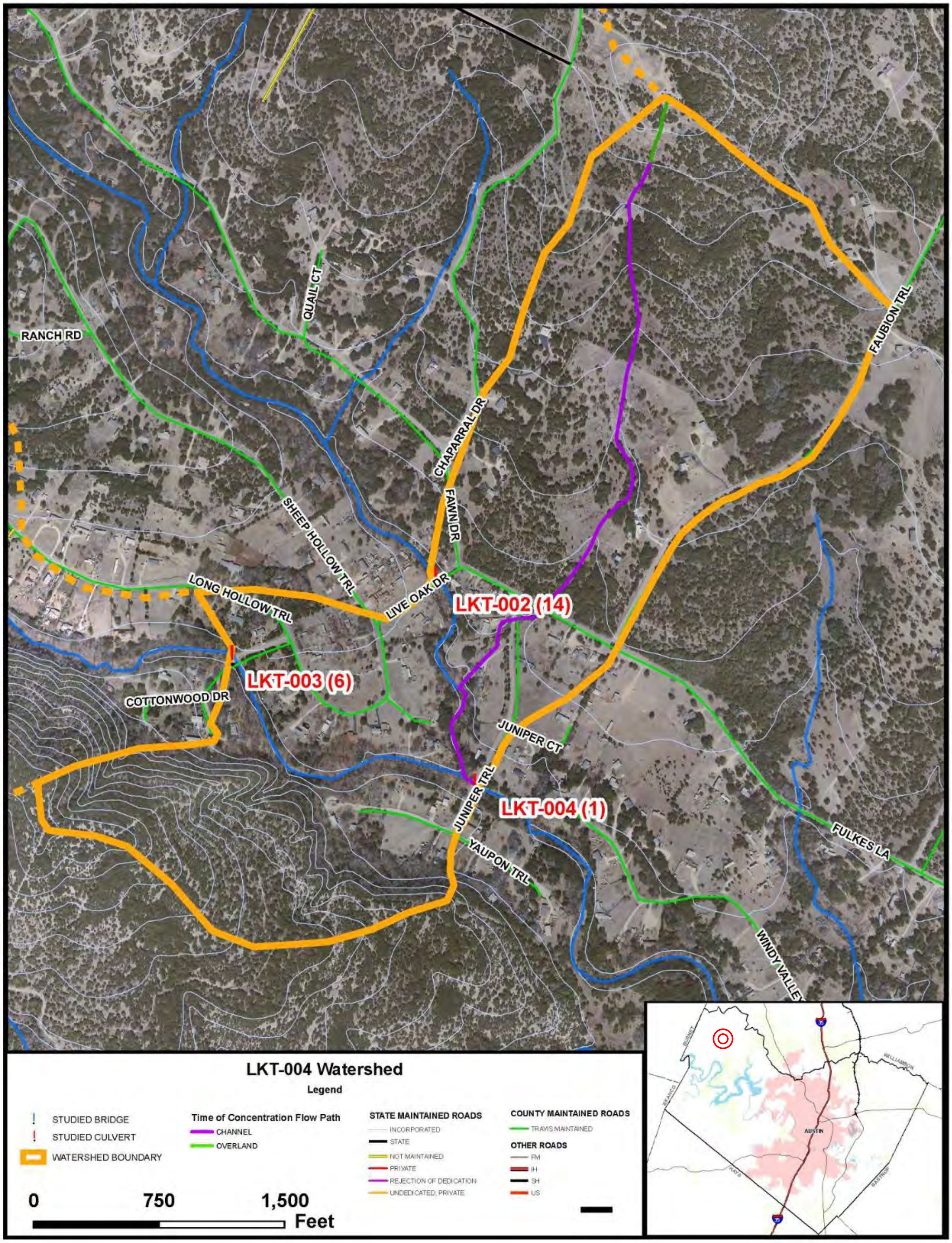



***Figure 5-6. Juniper Trail @ Long Hollow***

### *5.5.4 Wyldwood Road at Slaughter Creek & Tributary (SLA-004)*

Wyldwood Road crosses both Slaughter Creek and one of its major tributaries in the same area. Both are major waterways with watershed areas of approximately 13.1 and 4.9 square miles, respectively, at the Wyldwood Road crossing in southern Travis County as shown on Figure 5-7. The existing drainage structures are typical low water crossings consisting of three shallow 18" RCP at Slaughter Creek and two 18" RCP at the tributary, both at the bottom of steep sag vertical curves as shown in the photos below. The Slaughter Creek main channel crossing is included in the current effective FEMA FIS for Slaughter Creek as a Zone AE SFHA.

**Wyldwood Rd. at Slaughter Creek main channel.**

**Wyldwood Rd. at Tributary to Slaughter Creek.**

The following table provides a summary of discharges at the Slaughter Creek main channel crossing from the recent FEMA FIS:

| ***Existing Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 3,000* | 5,700 | 9,000* | 17,160 |
| *Interpolated flow | | | |

The following table provides a summary of computed discharges at the tributary crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Developed Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 1,450 | 3,327 | 4,440 | 6,293 | 1,629 | 3,609 | 4,772 | 6,699 |

Based on the FEMA FIS data for the main channel and the HDR analysis of the tributary, these stream crossings experience frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 6.18 feet and 3.20 feet, respectively. Wyldwood Road connects to Brodie Lane is also a single access way into a residential area including approximately 24 residences. Approximately three habitable structures are located within the FEMA 100-year floodplain directly upstream of the crossing. The drainage structures are in satisfactory condition with minor erosion downstream and moderate sedimentation upstream of the crossings. Based on field observations, the crossings appear to have a high potential for woody debris clogging.

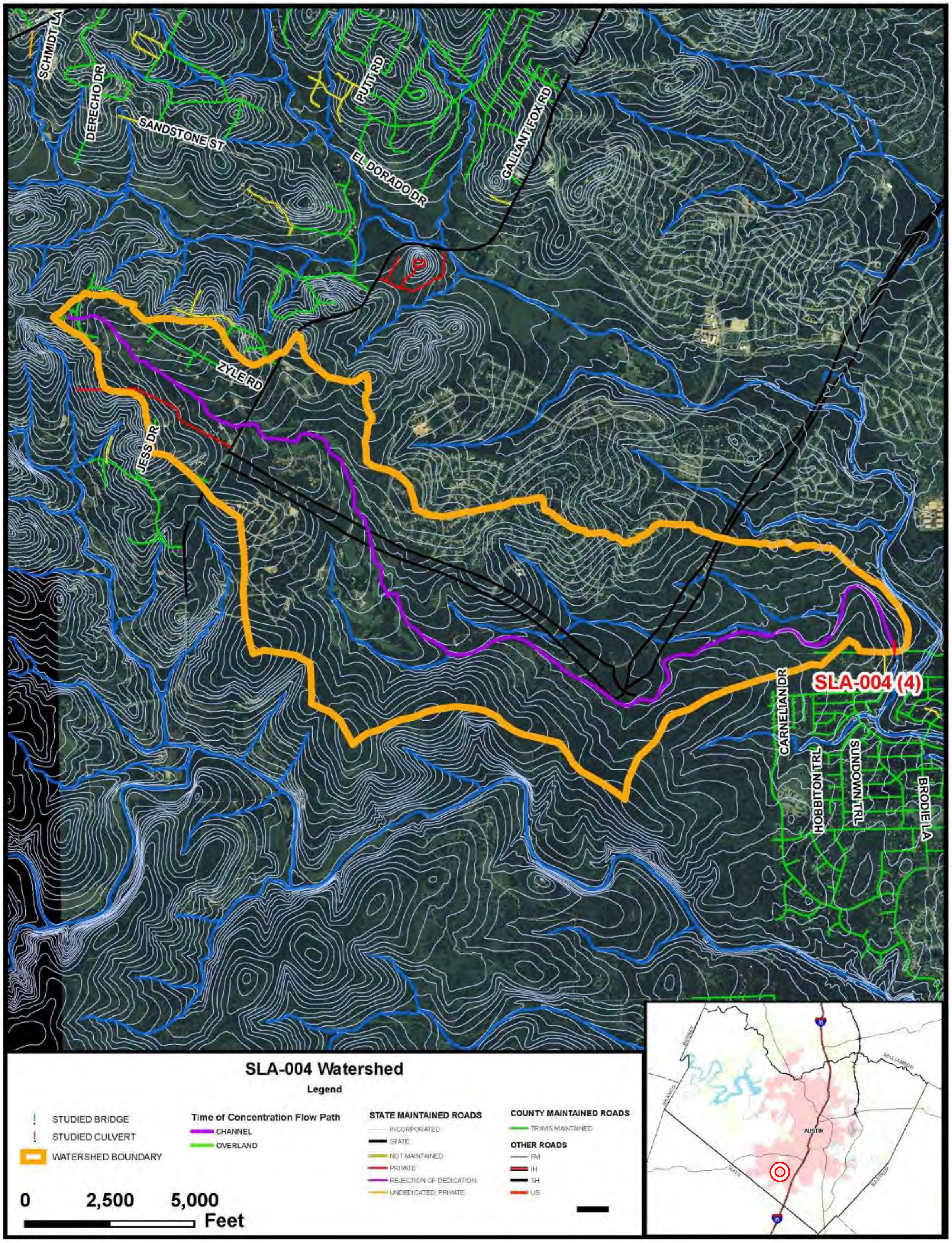
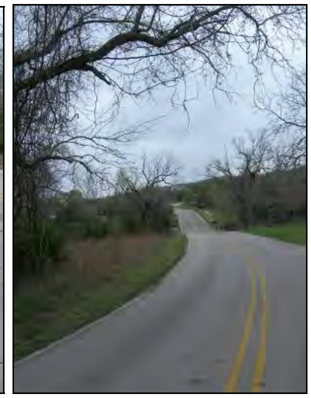



*Figure 5-7. Wyldwood Road @ Tributary to Slaughter Creek*

### 5.5.5 Great Divide Road at Little Barton Creek (LBA-001)

Little Barton Creek is a major waterway with a watershed area of 8.2 square miles at the Great Divide Road crossing in western Travis County as shown on Figure 5-8. The existing drainage structure is a low water crossing consisting of three shallow 18" CMP at the bottom of a sag vertical curve as shown in the photos below. This stream crossing is located within the unincorporated area of Travis County, however, the approach roadways are both located within the City of Bee Cave.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,045 | 5,322 | 7,340 | 10,750 | 2,343 | 5,790 | 7,878 | 11,382 |

With only these small pipes to pass stream flows, this low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 3.92 feet. A significant overtopping event from July of 2007 is shown in the photograph to the right. Great Divide Road connects to State Hwy. 71 and is a single access way into the Homestead Subdivision including over 150 residences. The drainage structure is in poor condition with minor erosion upstream and downstream of the crossing.

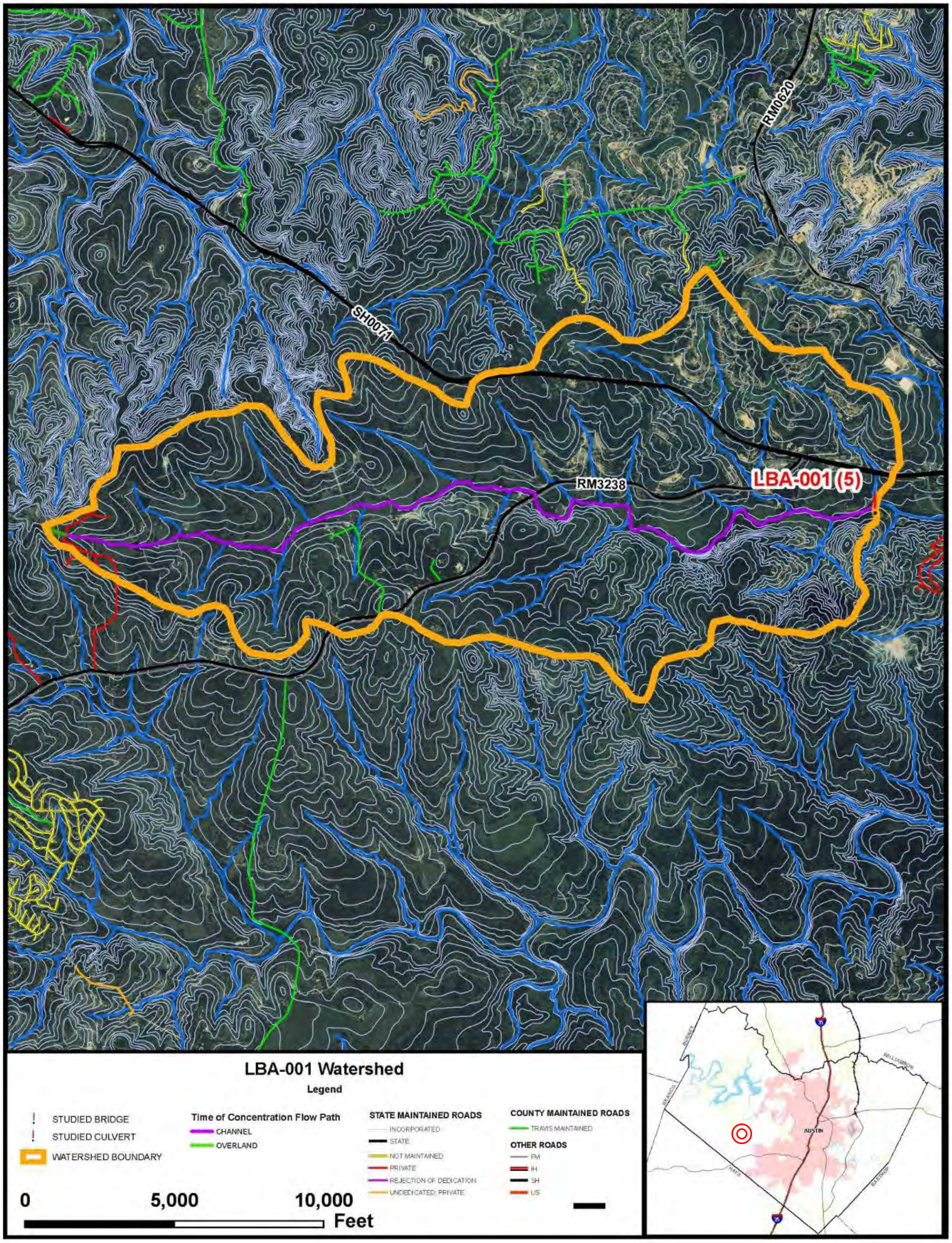



***Figure 5-8. Great Divide Road @ Little Barton Creek***

### *5.5.6 Fall Creek Road at Unnamed Tributary to Fall Creek (FAL-001)*

The Unnamed Tributary to Fall Creek is a major waterway with a watershed area of 2.0 square miles at the Fall Creek Road crossing in far western Travis County as shown on Figure 5-9. The existing drainage structure is a typical low water crossing consisting of one shallow 18" CMP at the low point of a relatively flat roadway as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 903 | 2,326 | 3,197 | 4,662 | 913 | 2,357 | 3,241 | 4,729 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 2.31 feet. Fall Creek Road is a direct link to State Hwy. 71 and is one of two primary access routes into a rural residential area including over 100 residences. The drainage structure is in fair condition with minor erosion and sedimentation problems at the crossing.

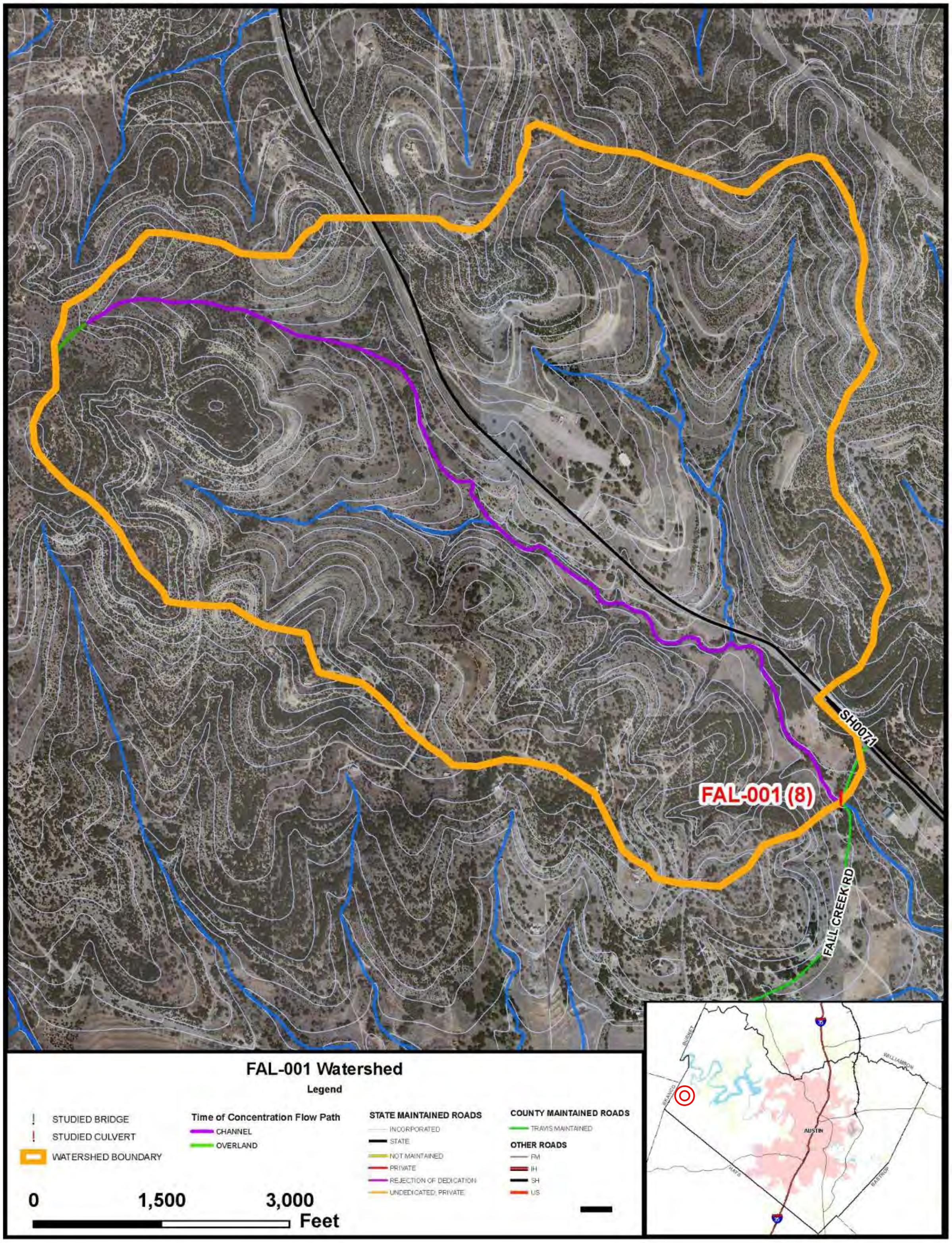



***Figure 5-9. Fall Creek Road @ Unnamed Tributary to Fall Creek***

### *5.5.7 Pedernales Canyon Trail at Lick Creek (LCK-001)*

Lick Creek is a major waterway with a watershed area of 3.3 square miles at the Pedernales Canyon Trail crossing as shown on Figure 5-10. The crossing is located at the confluence of Lick Creek and one of its large tributaries. Thus, there are two separate existing drainage structures each consisting of two shallow 36-inch diameter CMP as shown in the photos below.

The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 1,362 | 3,640 | 5,053 | 7,449 | 1,469 | 3,897 | 5,399 | 7,941 |

This stream crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 1.86 feet. During storm events equal to or greater than the 10-year event, both drainage crossings are submerged. Pedernales Canyon Trail connects to State Hwy. 71 and is a single access way into a residential area along the Pedernales River including over 50 residences. The drainage structures are in good condition with moderate erosion downstream of the crossing.

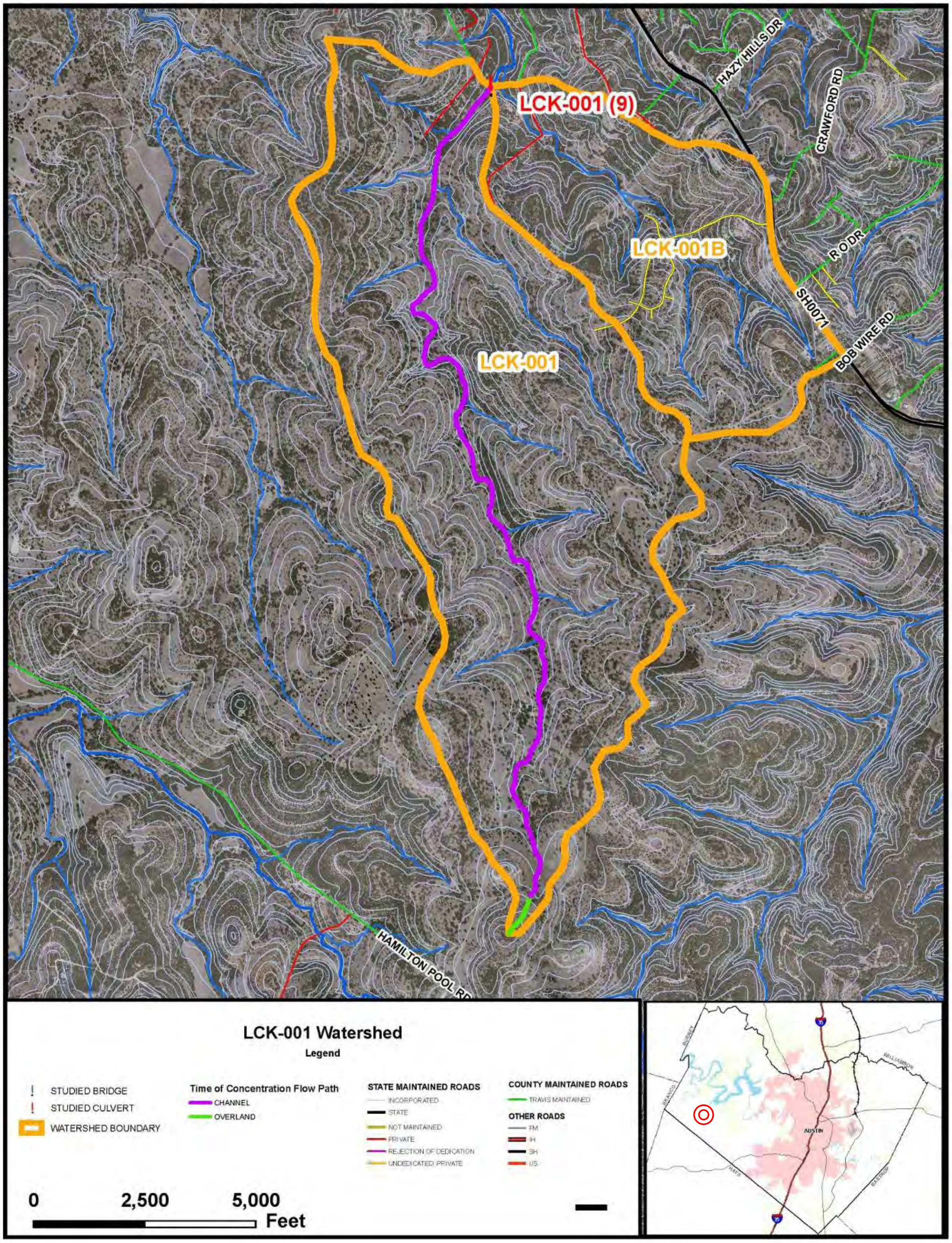



***Figure 5-10. Pedernales Canyon Trail @ Lick Creek***

### *5.5.8 Slaughter Creek Drive at Tributary 1 to Slaughter Creek (SLA-005)*

Tributary 1 to Slaughter Creek is major waterway with a watershed area of approximately 0.87 square miles at the Slaughter Creek Drive crossing in southern Travis County as shown on Figure 5-11. The existing drainage structure is a low water crossing consisting of two shallow 36-inch diameter CMP at the low point of a relatively flat roadway as shown in the photos below. This crossing is included in the current effective FEMA FIS for Slaughter Creek as a Zone AE SFHA.



The following table provides a summary of discharges at the crossing from the recent FEMA FIS:

| ***Existing Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 1,500* | 2,100 | 2,900* | 4,860 |
| *Interpolated flow | | | |

Based on the FEMA FIS data, this stream crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 1.80 feet. Slaughter Creek Drive connects to Slaughter Lane just west of IH-35 and is a single access way into a residential area including over 100 residences. The drainage structure is slightly impaired with moderate erosion downstream of the crossing. The downstream end treatment appears to experience frequent damage from erosion.

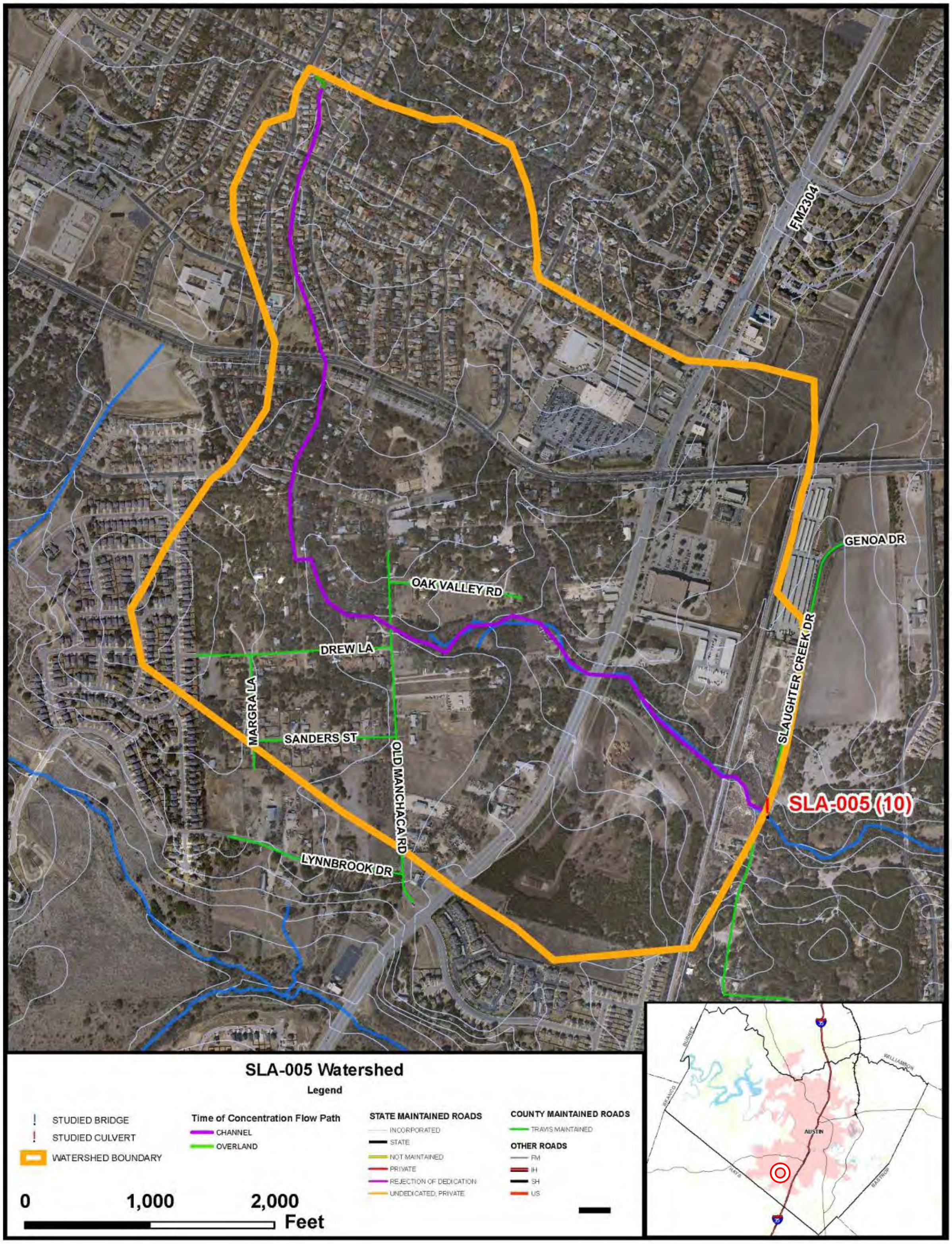



***Figure 5-11. Slaughter Creek Drive @ Trib 1 to Slaughter Creek***

### *5.5.9 Tumbleweed Trail at Unnamed Tributary to Lake Austin (LKA-001)*

The unnamed tributary is a large tributary to Lake Austin with a watershed area of 248 acres at the Tumbleweed Trail crossing in central Travis County as shown on Figure 5-12. The existing drainage structure is a low water crossing consisting of one shallow 36” RCP at the bottom of a steep sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 281 | 722 | 991 | 1,443 | 332 | 811 | 1,098 | 1,577 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 1.36 feet. Tumbleweed Trail is a single access way from Bee Caves Raod (RM 2244) and Cueravaca Drive into a residential area including over 50 residences. The drainage structure is in good condition with moderate erosion upstream of the crossing.

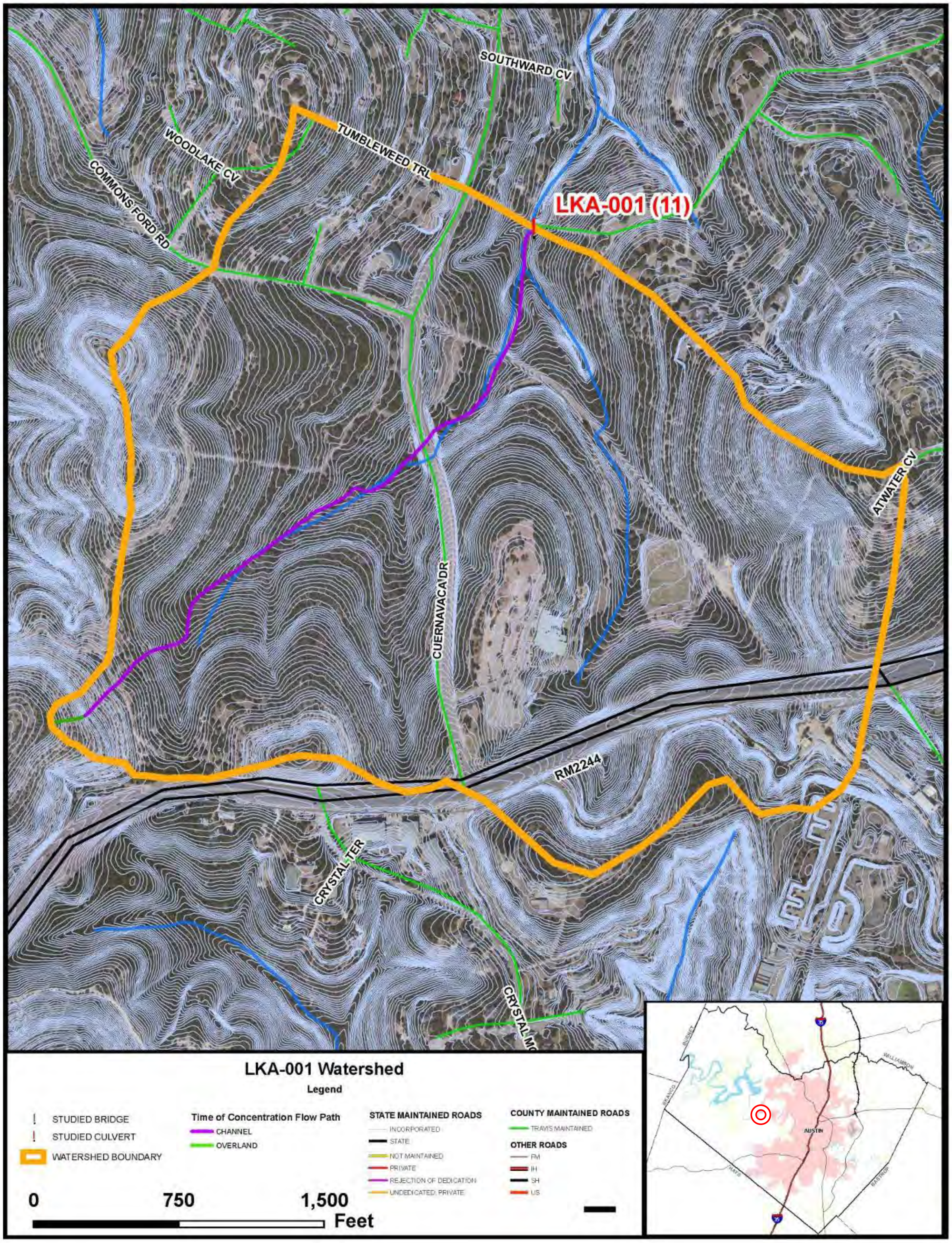



*Figure 5-12. Tumbleweed Trail @ Unnamed Trib to Lake Austin*

### *5.5.10 Crystal Bend Drive at Harris Branch (HRS-001)*

Harris Branch is a major waterway with a watershed area of approximately 4 square miles at the Crystal Bend Drive crossing in northeast Travis County as shown on Figure 5-13. The existing drainage structure consists of four 36-inch diameter CMP as shown in the photos below. This crossing is included in the current effective FEMA FIS for Harris Branch as a Zone AE SFHA.



The following table provides a summary of discharges at the crossing from the recent FEMA FIS:

| *Existing Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,500* | 3,430 | 4,400* | 6,730 |
| *Interpolated flow | | | |

Based on the FEMA FIS data, this stream crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 4.02 feet. Crystal Bend Drive connects to Dessau Road and is one of three primary access routes into a densely populated residential area. Approximately seven habitable structures are located within the FEMA 100-year floodplain directly upstream of the crossing. The drainage structure is in good condition with no significant erosion or sedimentation problems at the crossing. The crossing does appear to have a high potential for trash and woody debris clogging.

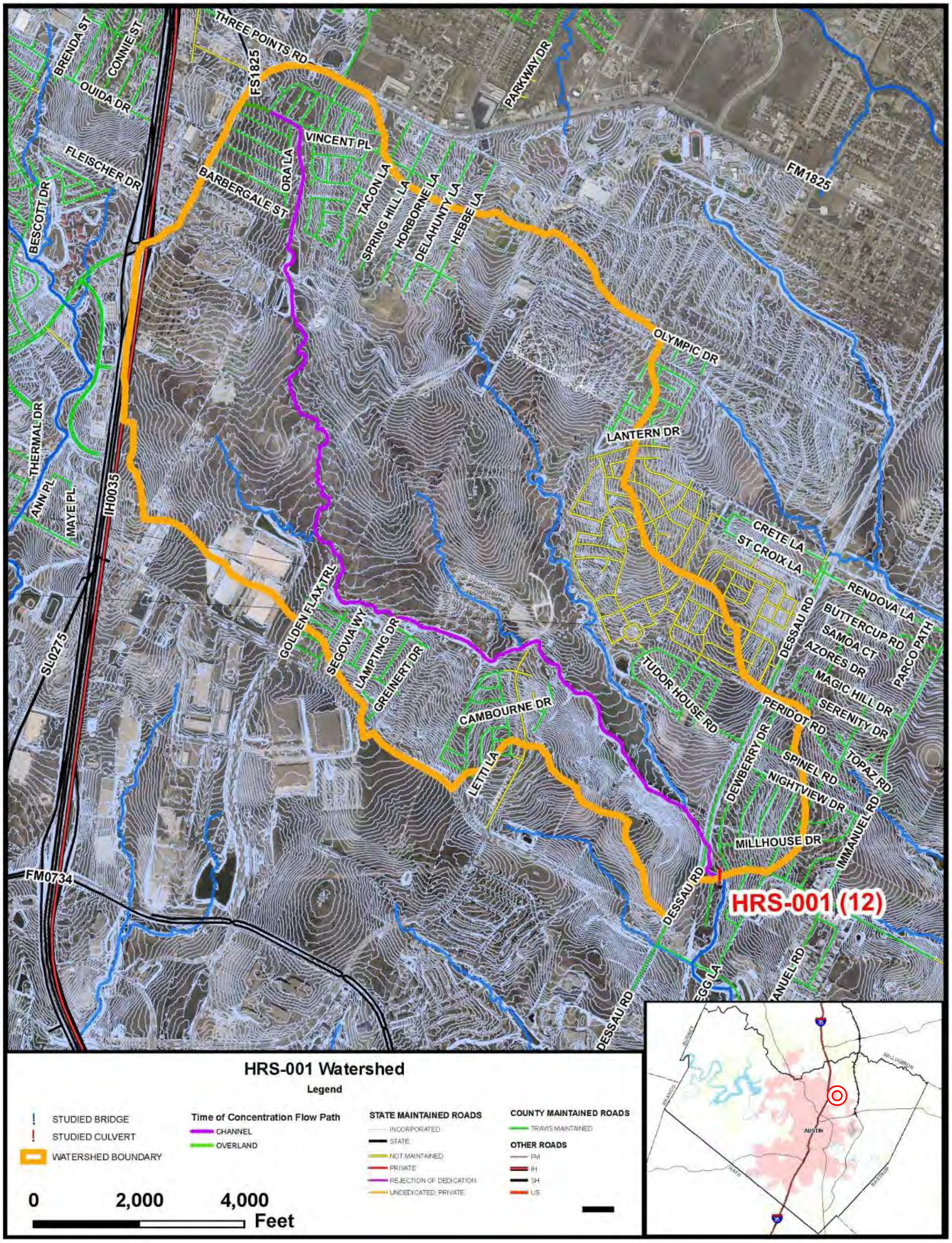



***Figure 5-13. Crystal Bend Drive @ Harris Branch***

### *5.5.11 Cottonwood Drive at Long Hollow (LKT-003)*

Long Hollow is a large tributary to Big Sandy Creek with a watershed area of 7.2 square miles at the Cottonwood Drive crossing in northwest Travis County as shown on Figure 5-14. The existing drainage structure is a typical low water crossing consisting of one shallow 60" CMP at the bottom of a sag vertical curve as shown in the photos below. This crossing is on the same stream as the Juniper Trail and Big Sandy crossings presented previously.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,047 | 5,196 | 7,119 | 10,355 | 2,204 | 5,427 | 7,378 | 10,646 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 4.92 feet as storm flows from the relatively large watershed overwhelm the crossing. Cottonwood Drive is also a single access way into a residential area including approximately 7 residences. At least one habitable structure LFE is below the computed 100-year floodplain directly upstream of the crossing. The drainage structure is in satisfactory condition with moderate erosion downstream and of the crossing.

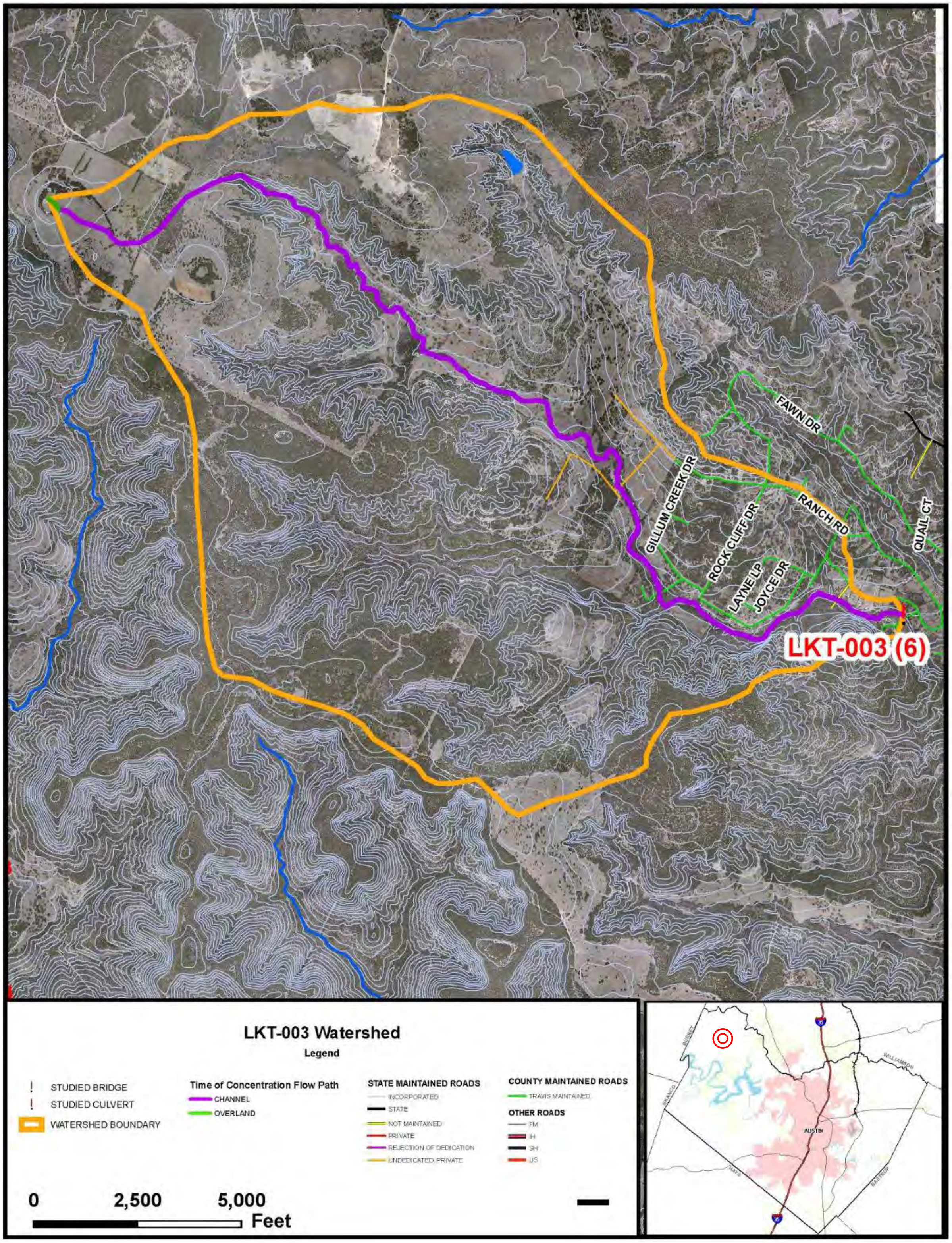



***Figure 5-14. Cottonwood Drive @ Long Hollow***

### *5.5.12 Jacobson Road at Maha Creek (MAH-008)*

Maha Creek is major waterway with a watershed area of approximately 14.4 square miles at the Jacobson Road crossing in eastern Travis County as shown on Figure 5-15. The existing drainage structure is a 213-foot five-span slab beam bridge as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| *2-Yr* | *10-Yr* | *25-Yr* | *100-Yr* | *2-Yr* | *10-Yr* | *25-Yr* | *100-Yr* |
| 1,919 | 5,562 | 7,901 | 12,057 | 2,159 | 6,009 | 8,428 | 12,678 |

The existing bridge is perched above the computed 100-year floodplain and does not overtop. However, a long section of Jacobson Road east of the existing bridge is located below the computed 2-year floodplain as shown in Table 4.2 and Appendix B. This section of roadway experiences frequent and severe overtopping with a depth of overtopping from a 2-year storm event of 1 foot. Jacobson Road provides a single access way into a residential area that includes 6 residences. At least five habitable structures are located within the computed 100-year floodplain directly upstream of the crossing. The bridge structure is in good condition with no significant erosion or sedimentation problems at the crossing.

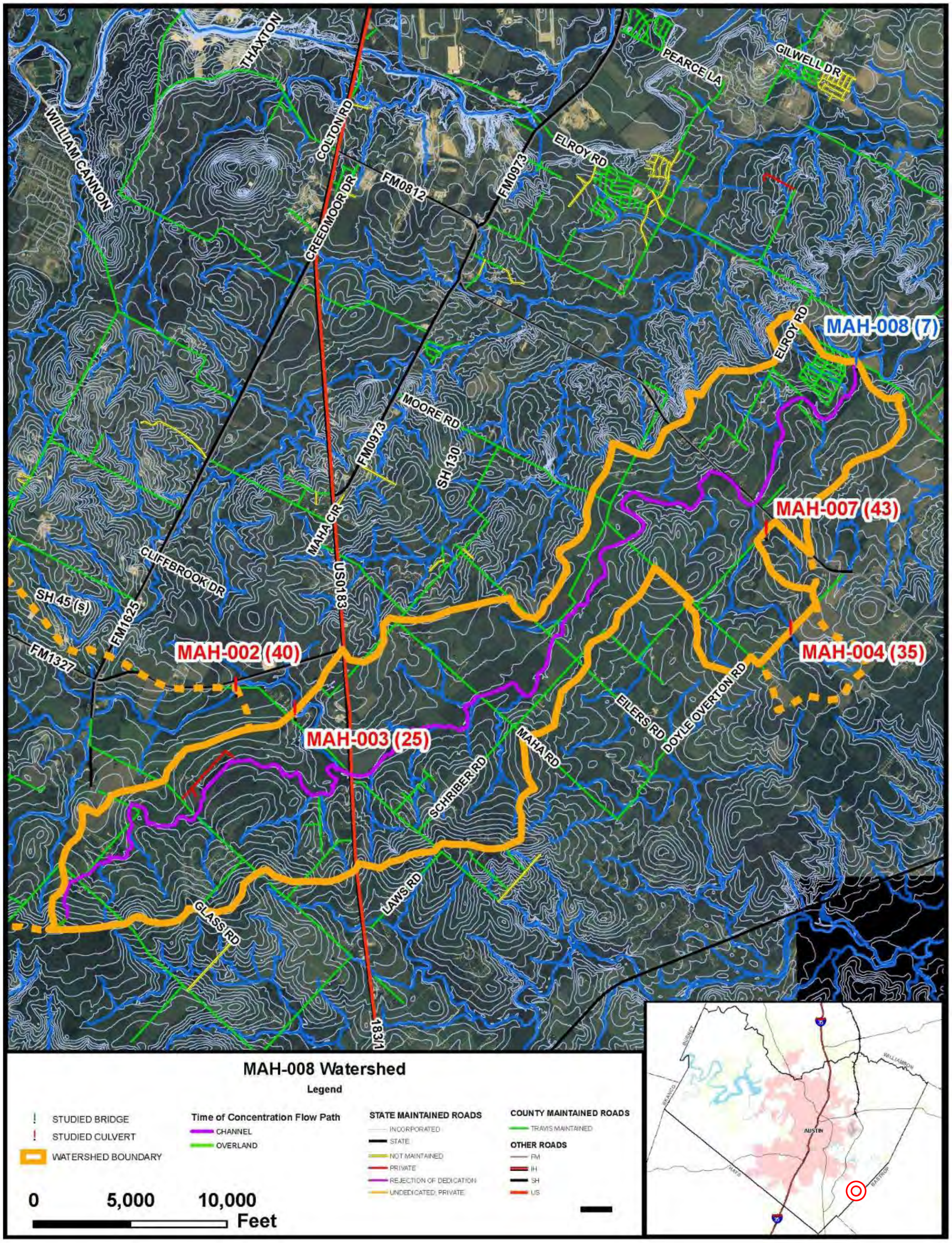



*Figure 5-15. Jacobson Road @ Maha Creek*

### *5.5.13 Linden Road at Maha Creek (MAH-009)*

Maha Creek is a major waterway with a watershed area of 1.6 square miles at the Linden Road crossing in southeast Travis County as shown on Figure 5-16. The existing drainage structure is a typical low water crossing consisting of four shallow 10’x4’ RCB culverts at the low point of a relatively flat roadway as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 1,878 | 5,452 | 7,781 | 11,953 | 2,114 | 5,893 | 8,304 | 12,573 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B with a depth of overtopping from a 2-year storm event of 2.39 feet. Linden Road connects to Pierce Lane and is one of two access ways into a residential area including approximately 7 residences. At least one habitable structure is located within the computed 100-year floodplain directly upstream of the crossing. The drainage structure is in good condition with minor erosion and sedimentation problems at the crossing.

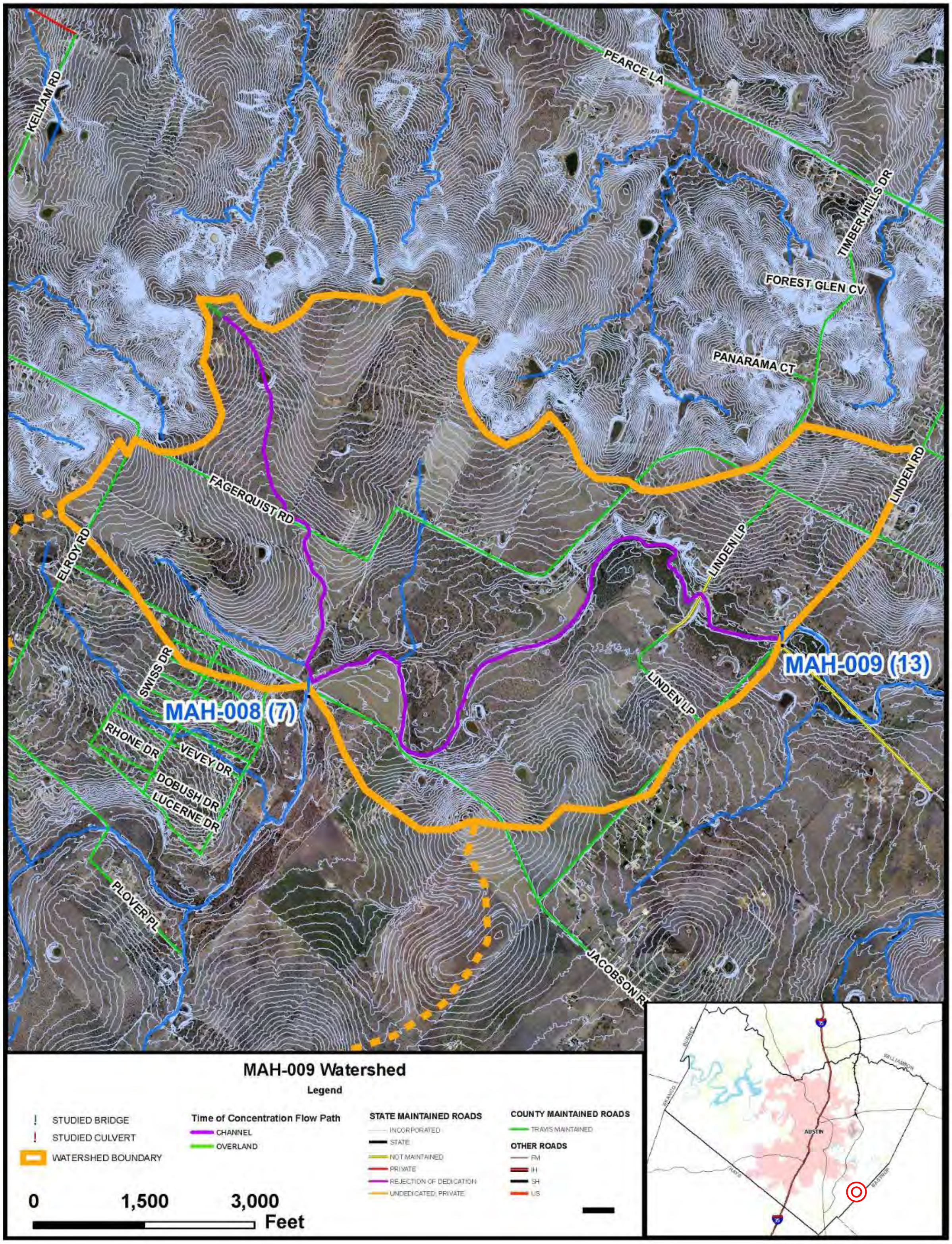



*Figure 5-16. Linden Road @ Maha Creek*

### *5.5.14 Live Oak Drive at Sheep Hollow (LKT-002)*

Sheep Hollow is a large tributary to Long Hollow with a watershed area of 1.4 square miles at the Live Oak Drive crossing in northwest Travis County as shown on Figure 5-17. The existing drainage structure is a low water crossing consisting of three shallow 24-inch diameter RCP at the bottom of a steep sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| *2-Yr* | *10-Yr* | *25-Yr* | *100-Yr* | *2-Yr* | *10-Yr* | *25-Yr* | *100-Yr* |
| 584 | 1,506 | 2,072 | 3,022 | 614 | 1,568 | 2,151 | 3,130 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 1.97 feet. Live Oak Drive is one of two primary access ways into a residential area including over 100 residences. At least one habitable structure LFE is below the computed 100-year floodplain directly upstream of the crossing. The drainage structure is in fair condition with no significant erosion or sedimentation problems at the crossing.

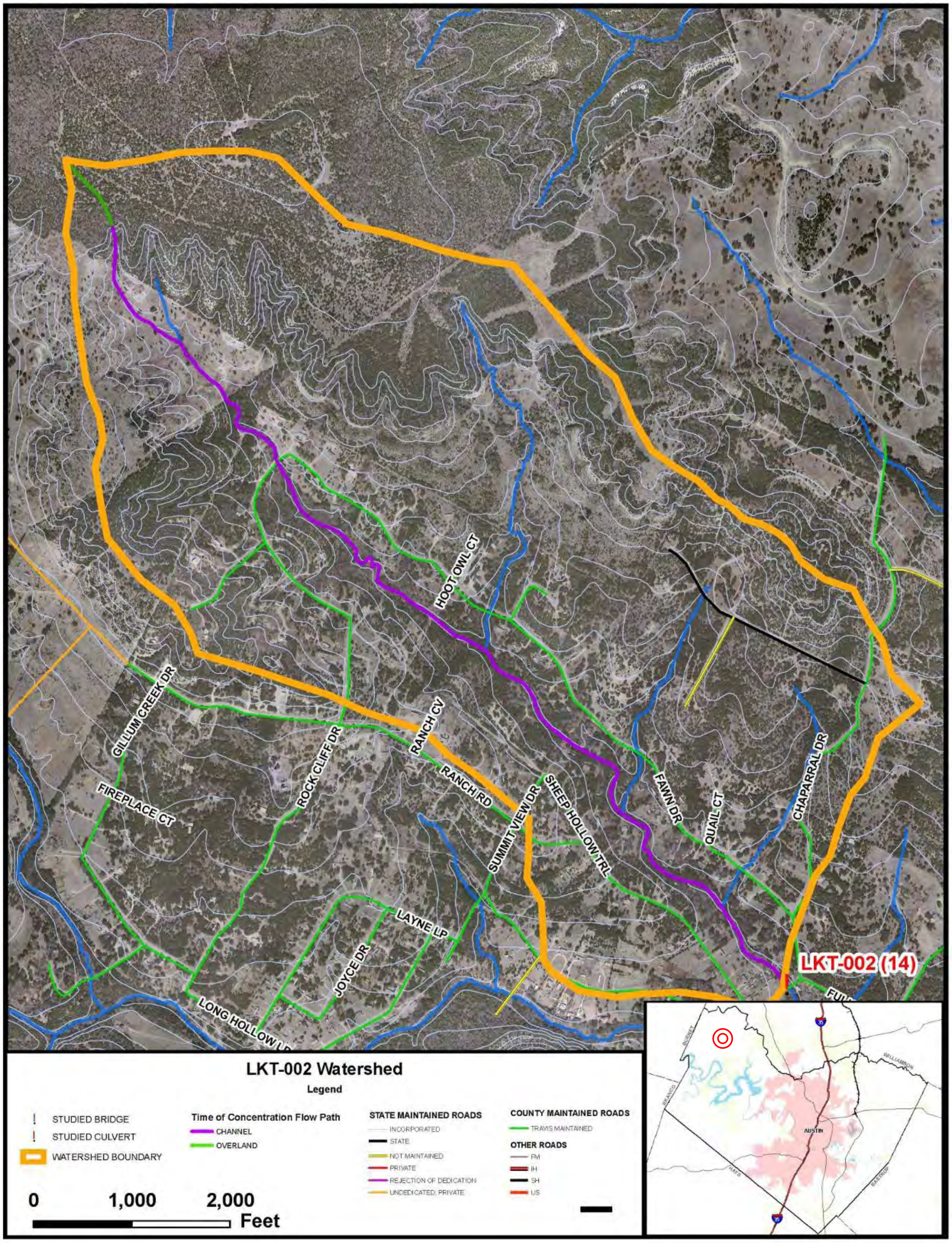



***Figure 5-17. Live Oak Drive @ Sheep Hollow***

### *5.5.15 Springdale Road at Tributary 5 to Walnut Creek (WLN-002)*

Tributary 5 is a major tributary to Walnut Creek with a watershed area of approximately 1.2 square miles at the Springdale Road crossing in eastern Travis County as shown on Figure 5-18. The existing drainage structure is an 8' x 10' box culvert as shown in the photos below. This crossing is included in the current effective FEMA FIS of Tributary 5 to Walnut Creek as a Zone AE SFHA.



The following table provides a summary of discharges at the crossing from the recent FEMA FIS:

| ***Existing Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 1,600* | 2,160 | 2,750* | 4,280 |
| *Interpolated flow | | | |

Based on the FEMA FIS data, this stream crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 2.11 feet. Springdale Road connects to US Hwy. 290 and is one of two primary access routes into a residential neighborhood including over 100 residences. One habitable structure encroaches the FEMA 100-year floodplain directly upstream of the crossing. The drainage structure is in satisfactory condition with no significant erosion or sedimentation problems at the crossing.

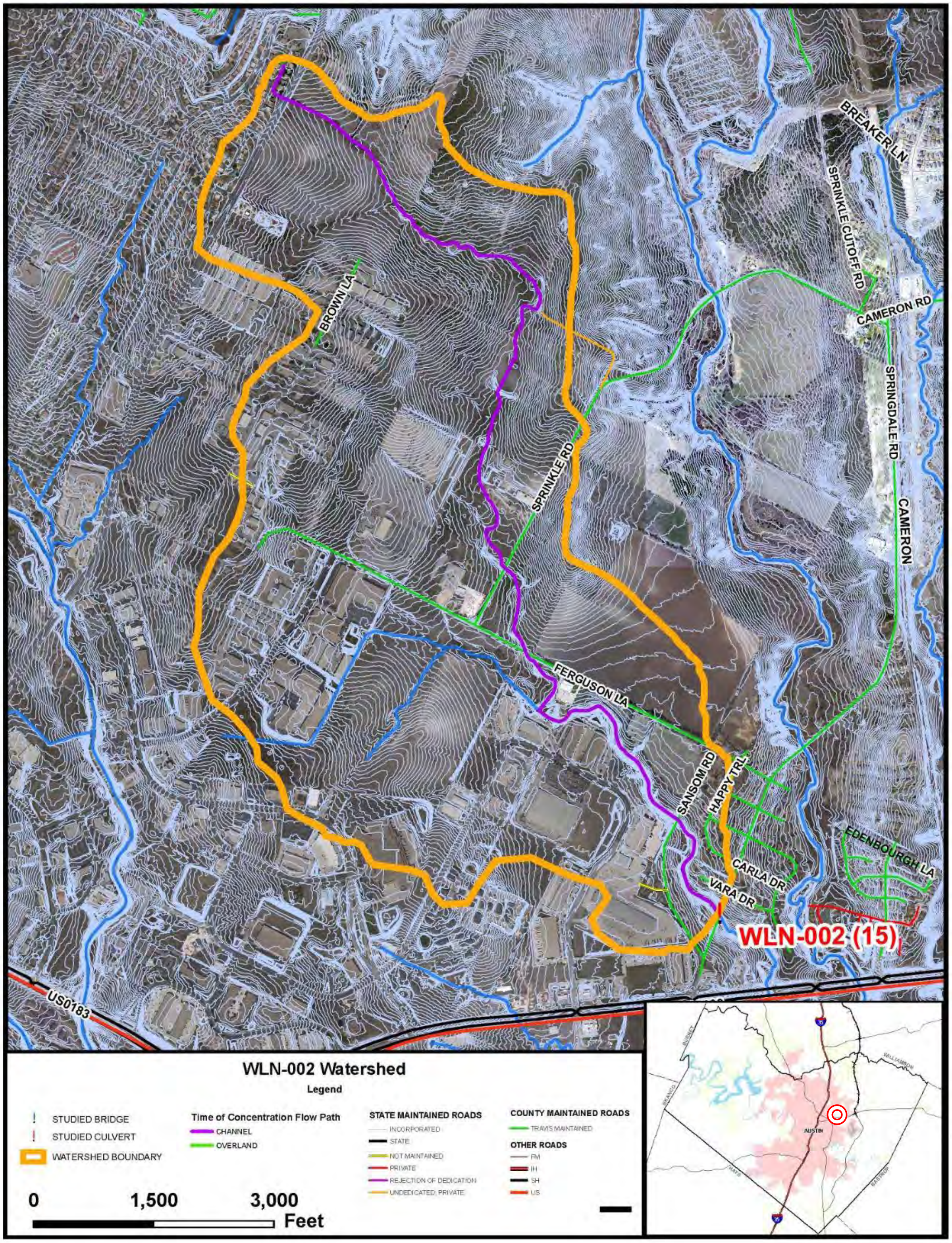
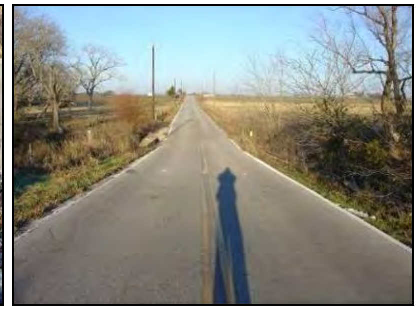



*Figure 5-18. Springdale Road @ Trib 5 to Walnut Creek*

### *5.5.16 Gregg Lane at Wilbarger Creek (WLB-004)*

Wilbarger Creek is a major waterway with a watershed area of 1.6 square miles at the Gregg Lane crossing in northeast Travis County, east of Pflugerville as shown on Figure 5-19. The existing drainage structure is a low water crossing consisting of two 10-ft concrete spans at the low point of a relatively flat roadway as shown in the photos below.





The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,331 | 7,410 | 10,028 | 14,659 | 3,694 | 8,339 | 11,043 | 15,776 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 2.67 feet. Overtopping from a moderate storm event in May 2008 is shown in the photos below. Gregg Lane connects to FM 973 and is one of two primary access routes for 3 rural residences. The drainage structure is in satisfactory condition with no significant erosion or sedimentation problems at the crossing.



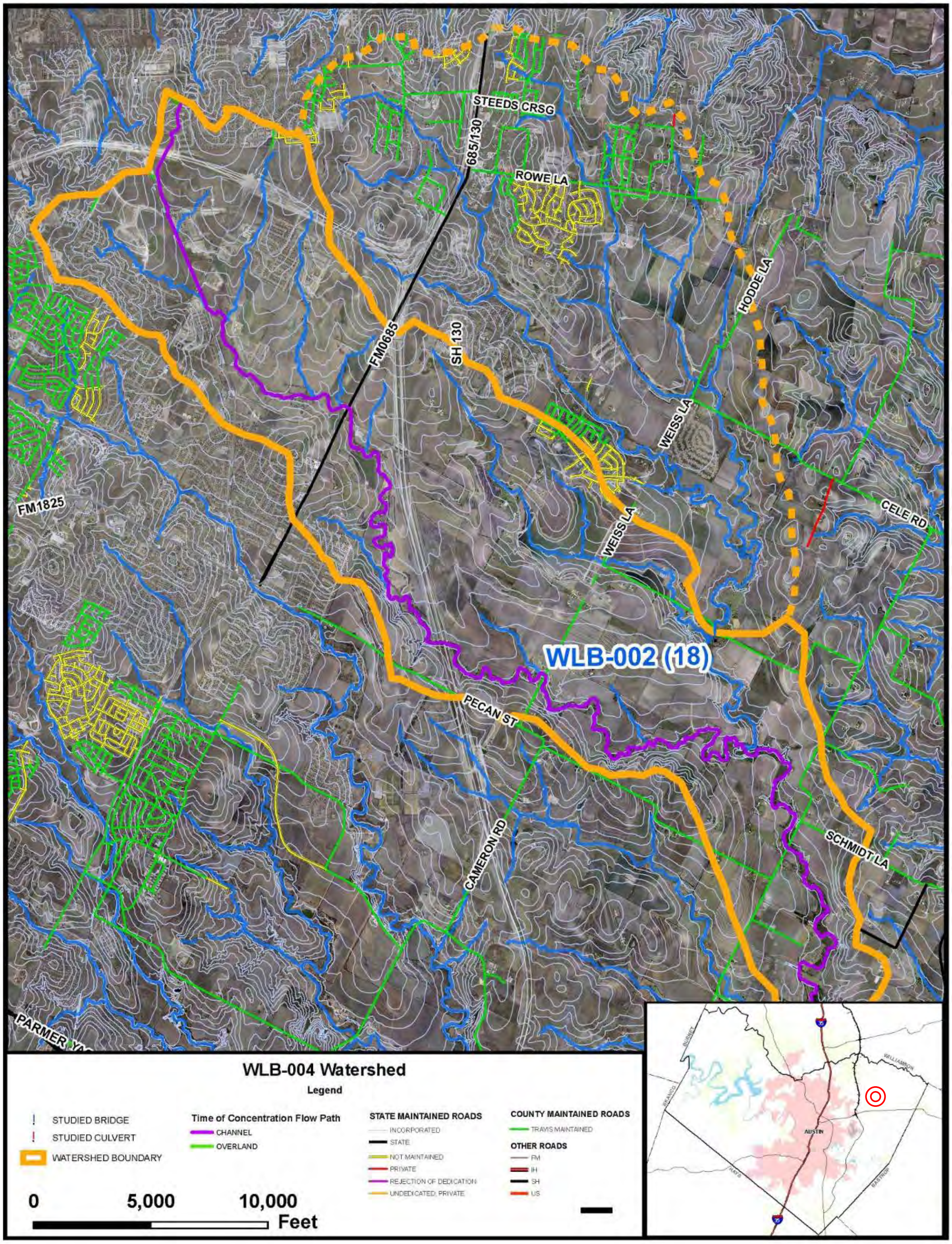



***Figure 5-19. Gregg Lane @ Wilbarger Creek***

### *5.5.17 Jesse Bohls Road at Unnamed Tributary to Wilbarger Creek (WLB-002)*

The unnamed tributary to Wilbarger Creek is a major waterway with a watershed area of 10.4 square miles at the Jesse Bohls Road crossing in northeast Travis County east of Pflugerville as shown on Figure 5-20. The existing drainage structure consists of four 14-ft concrete spans at the crossing on a relatively flat roadway as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,360 | 5,399 | 7,206 | 10,217 | 2,859 | 6,045 | 7,900 | 10,969 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 1.8 feet. Jesse Bohls Road connects to Weiss Lane at Cameron Road and is one of two primary access routes for approximately 8 rural residences. The drainage structure is in satisfactory condition with no significant erosion or sedimentation problems at the crossing.

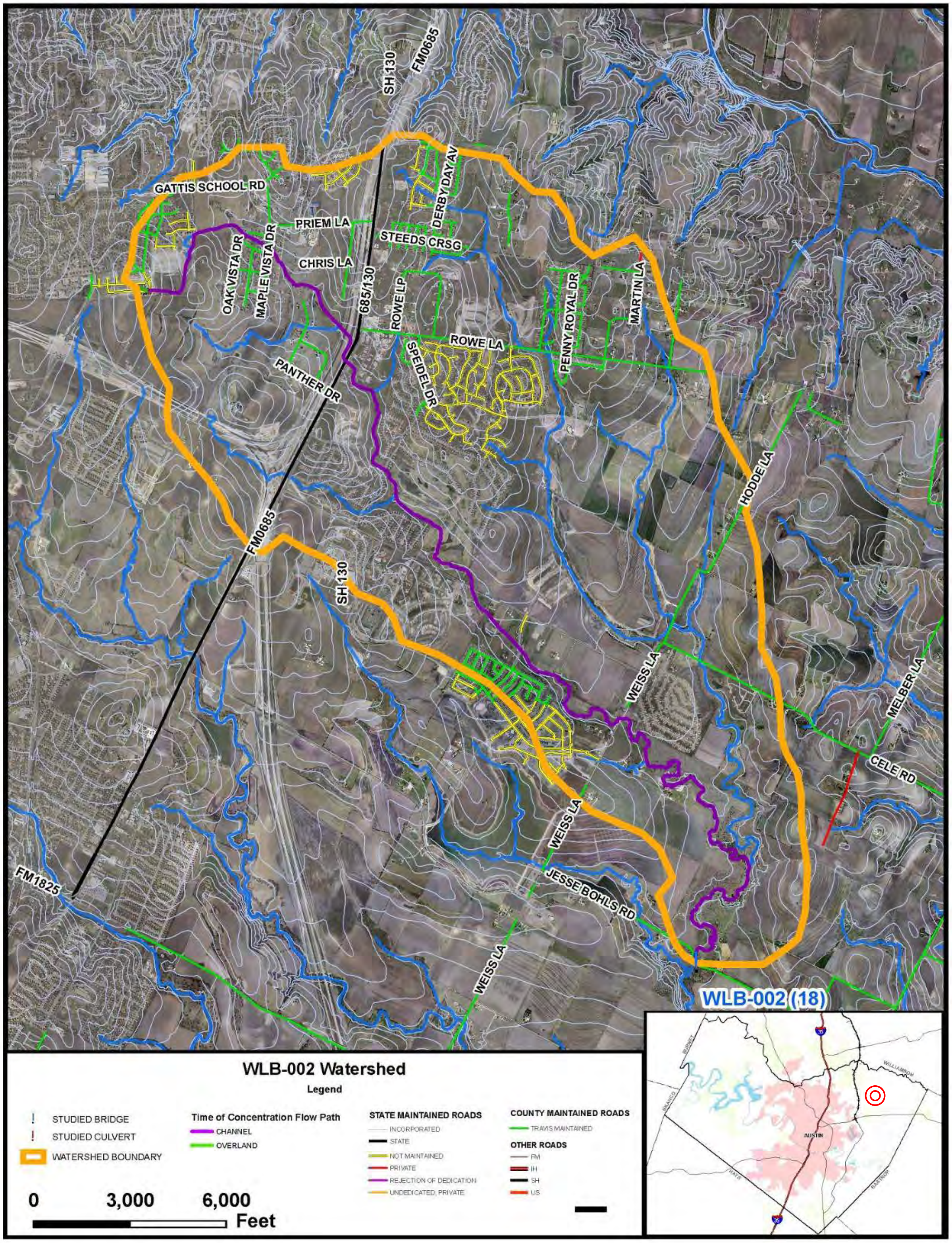



*Figure 5-20. Jesse Bohls Rd. @ Unnamed Trib to Wilbarger Creek*

### *5.5.18 Lime Creek Road at Fisher Hollow (LKT-010)*

Fisher Hollow is a large tributary to Lime Creek with a watershed area of 0.86 square miles at the Lime Creek Road crossing north of Lake Travis in north Travis County as shown on Figure 5-21. The existing drainage structure is a typical low water crossing consisting of one shallow 15” CMP at the bottom of a steep sag vertical curve as shown in the photos below.

The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 511 | 1,201 | 1,611 | 2,294 | 575 | 1,321 | 1,762 | 2,492 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 2.7 feet. Lime Creek Road connects to Anderson Mill Rd. to the north of the crossing and Volente Rd. to the south and is one of two primary access routes for over 15 rural residences and businesses. The drainage structure is in good condition with no significant erosion or sedimentation problems at the crossing.

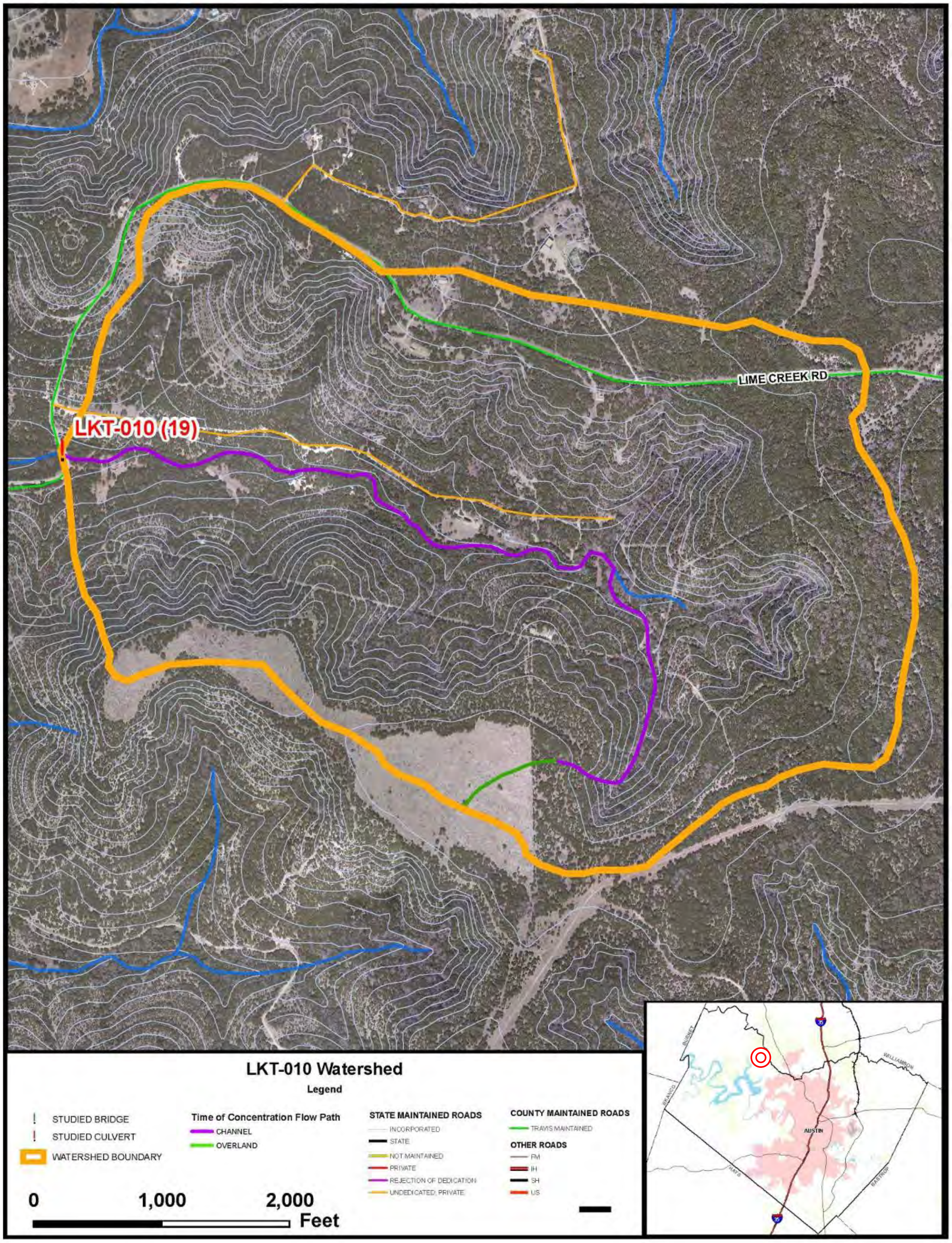
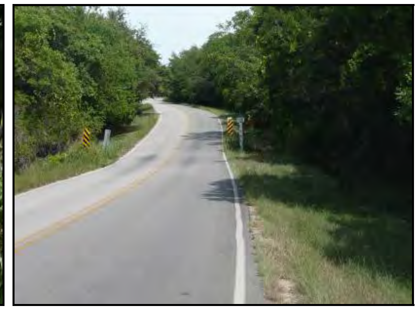



***Figure 5-21. Lime Creek Road @ Fisher Hollow***

### *5.5.19 Nameless Road at Unnamed Tributary to Big Sandy (LKT-001)*

The unnamed tributary to Big Sandy Creek is a large tributary with a watershed area of 0.86 square miles at the Nameless Road crossing near Honeycomb Drive in north Travis County as shown on Figure 5-22. The existing drainage structure is a typical low water crossing consisting of one shallow 24” RCP at the bottom of a sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 458 | 1,101 | 1,486 | 2,128 | 478 | 1,143 | 1,541 | 2,203 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 1.42 feet. Nameless Road is one of two primary access routes for a rural neighborhood of over 50 residences. The drainage structure is in fair condition with minor erosion at the downstream end of the crossing. The crossing appears to have a high potential for clogging from woody debris.

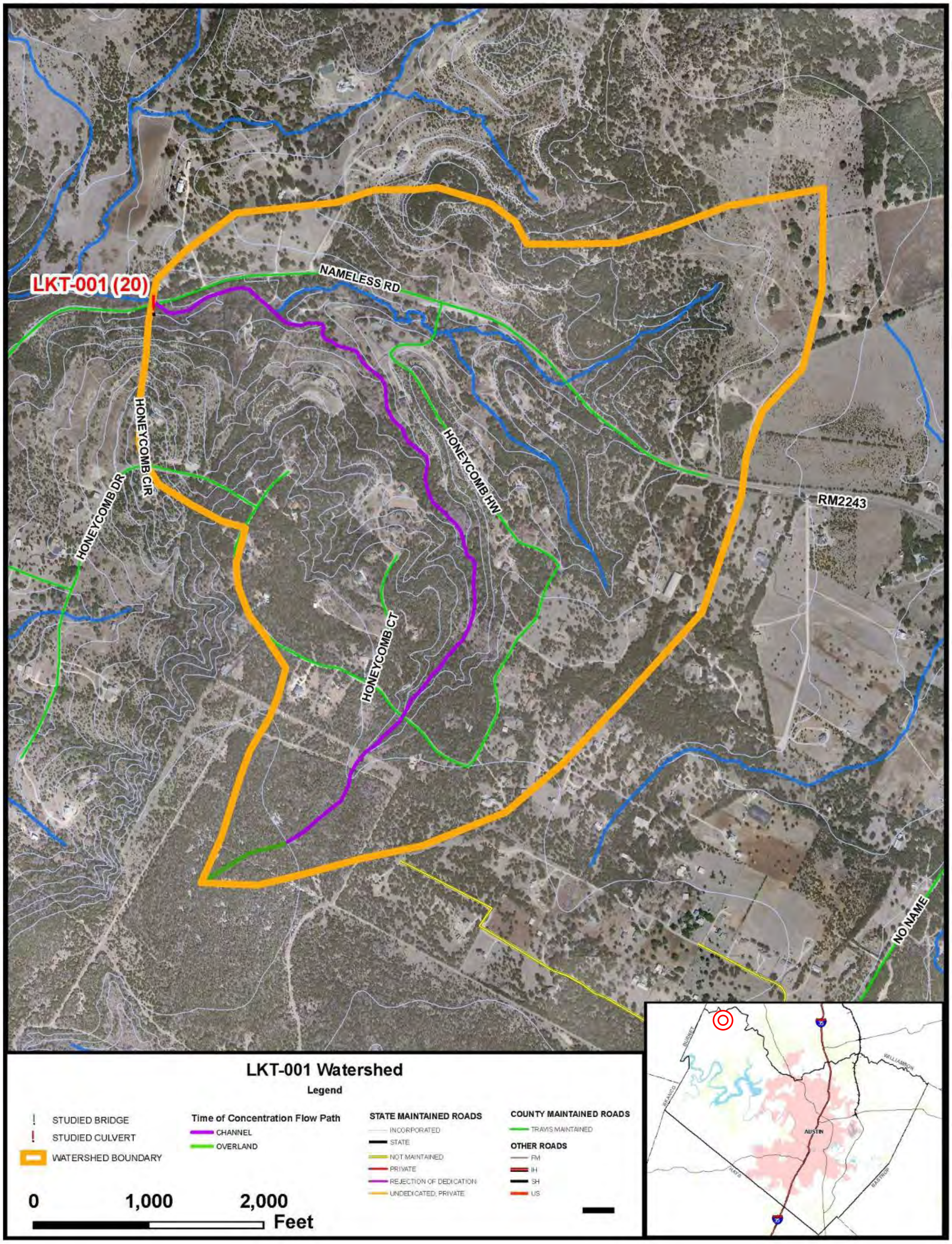



*Figure 5-22. Nameless Road @ Unnamed Tributary to Big Sandy*

### *5.5.20 D Morgan Road at Unnamed Tributary to Grape Creek (WBC-001)*

The unnamed tributary is a major tributary to Grape Creek with a watershed area of 371.5 acres at the D Morgan Road crossing in south Travis County as shown on Figure 5-23. The existing low water crossing has no drainage structure. All storm events flow over the roadway at the low point of the sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| **2-Yr** | **10-Yr** | **25-Yr** | **100-Yr** | **2-Yr** | **10-Yr** | **25-Yr** | **100-Yr** |
| 299 | 784 | 1,082 | 1,583 | 336 | 849 | 1,161 | 1,682 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 1.21 feet. During field inspection of the crossing after a storm event that produced approximately 2 inches of rainfall, flow over the road was approximately 6 to 8 inches deep. D Morgan Road is a single access way into a rural residential area including approximately 3 residences. Minor erosion exists on the downstream side of the crossing.

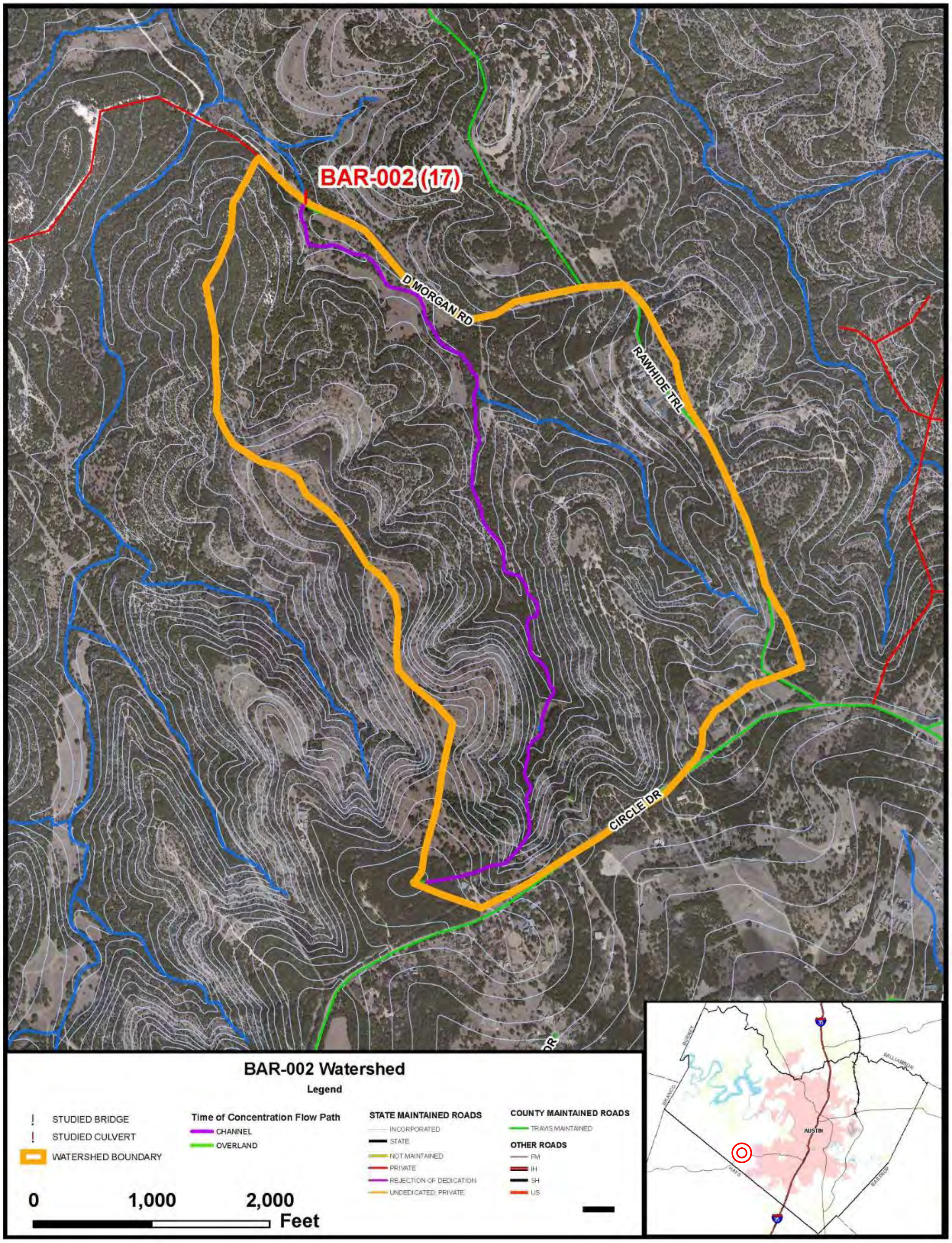



***Figure 5-23. D Morgan Road @ Unnamed Trib to Grape Creek***

### *5.5.21 Bee Creek Road at Bee Creek (WBC-001)*

Bee Creek is a major waterway with a watershed area of 13.12 square miles at the Bee Creek Road crossing as shown on Figure 5-24. The existing drainage structure is a typical low water crossing consisting of three shallow 24" RCP at the bottom of a sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,492 | 6,916 | 9,765 | 14,720 | 2,818 | 7,449 | 10,386 | 15,478 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with a depth of overtopping from a 2-year storm event of 4.73 feet. A significant overtopping event from March of 2007 is shown in the photographs below. Bee Creek Road is a rural residential collector roadway. The drainage structure is in fair condition with no significant erosion or sedimentation problems at the crossing.



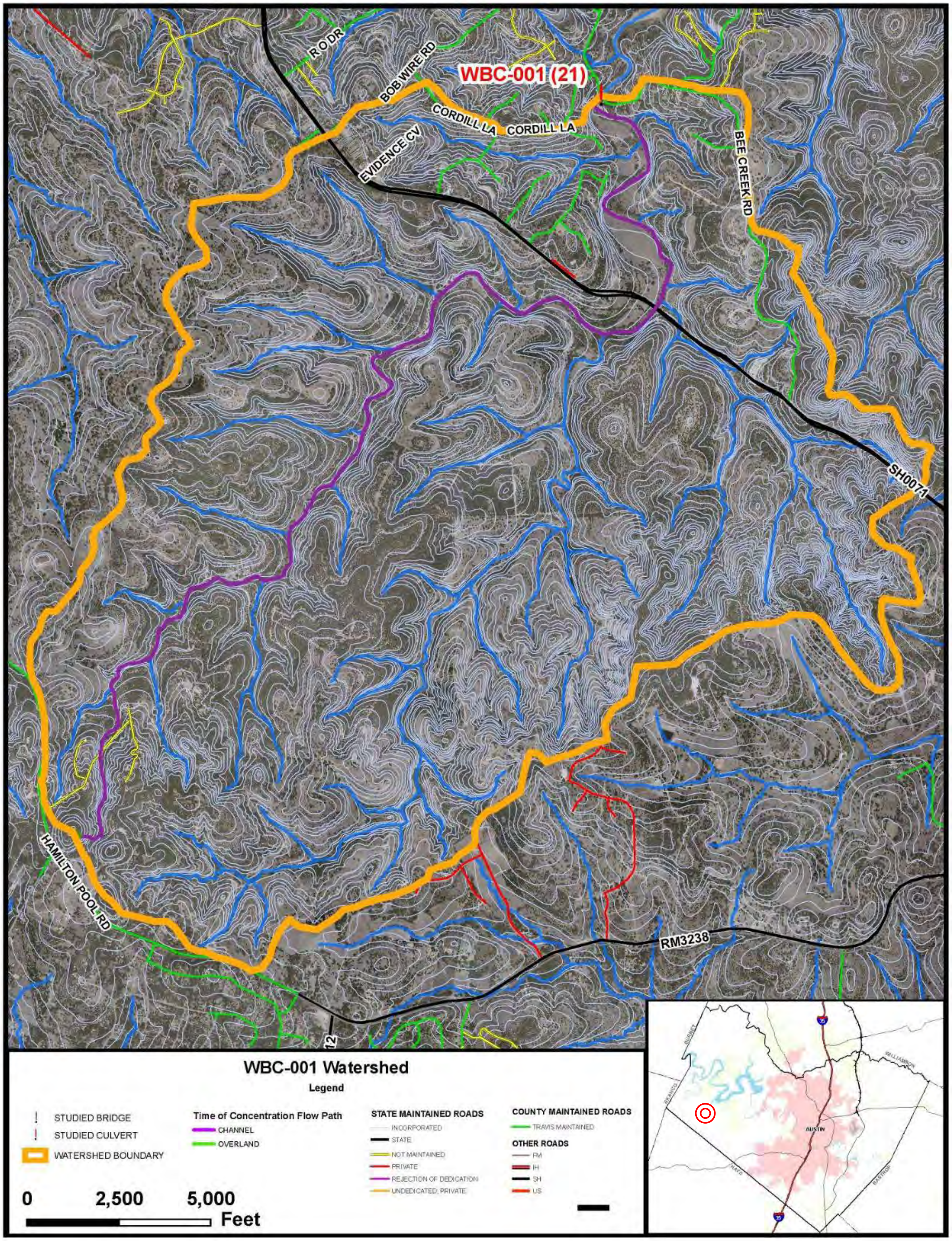



***Figure 5-24. Bee Creek Road @ Bee Creek***

### *5.5.22 Navarro Creek Road at Navarro Creek (DRE-006)*

Navarro Creek is a large tributary to Dry East Creek with a watershed area of 1.6 square miles at the Navarro Creek Road crossing as shown on Figure 5-25. The existing drainage structure is a typical low water crossing consisting of two shallow 48” CMP at the low point of a relatively flat roadway as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 586 | 1,448 | 1,969 | 2,843 | 741 | 1,666 | 2,210 | 3,112 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with an overtopping depth from the 100-year storm event of 2.08 feet. Navarro Creek Road is also a single access way into a rural residential area including approximately 36 residences. The drainage structure is in fair condition with minor erosion at the downstream side of the crossing. The crossing appears to have potential for clogging from woody debris.

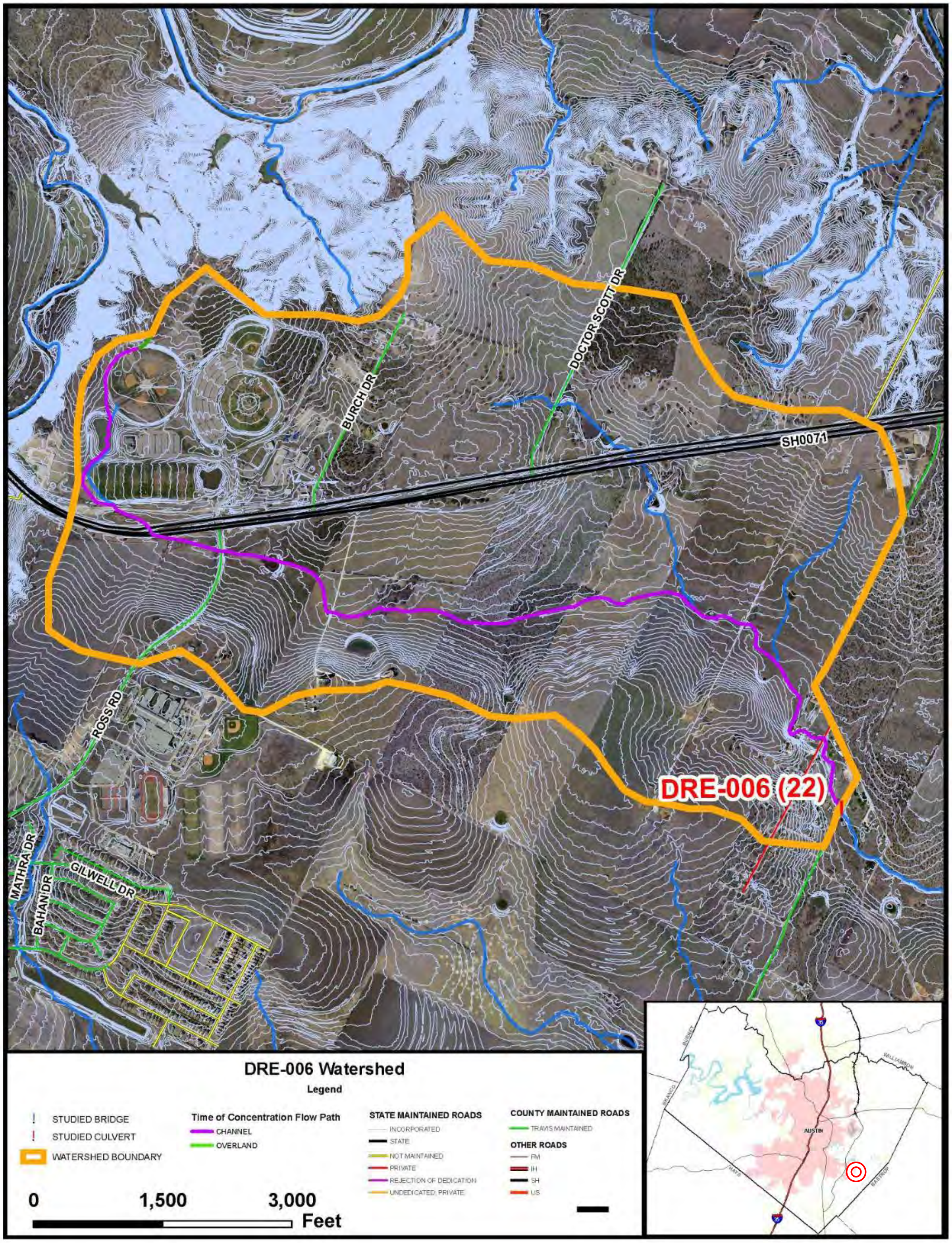



***Figure 5-25. Navarro Creek Rd @ Navarro Creek***

### *5.5.23 Bitting School Road at Unnamed Tributary to Wilbarger Creek (WLB-012)*

The unnamed tributary is a large tributary to Wilbarger Creek with a watershed area of 315.64 acres at the Bitting School Road crossing as shown on Figure 5-26. This crossing is adjacent to the Wilbarger Creek main channel crossing which has a contributing watershed area of 53.7 square miles. The existing drainage structure at the unnamed tributary is a typical low water crossing consisting of four shallow 60” CMP at the low point of a relatively flat roadway as shown in the photos below.



This crossing becomes inundated by the adjacent Wilbarger Creek main channel floodplains for the 10-, 25-, and 100-year storm events. The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 187 | 22,579 | 32,089 | 48,369 | 262 | 23,866 | 33,623 | 50,929 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with an overtopping depth from the 100-year storm event of 7.28 feet. Bitting School Road is one of two primary access routes for approximately 8 rural residences and 1 business.

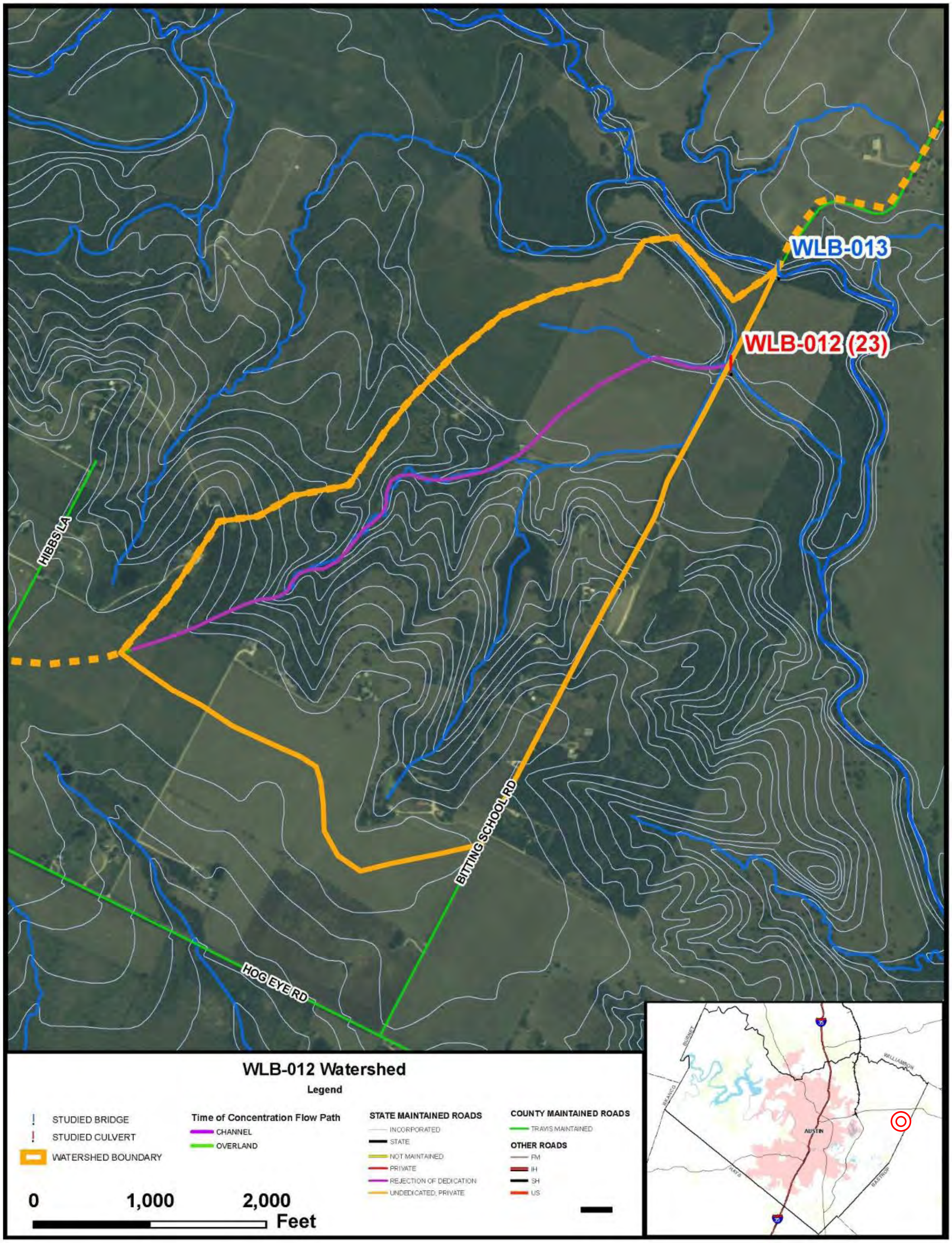



***Figure 5-26. Bitting School Road @ Unnamed Trib to Wilbarger Creek***

### *5.5.24 Weir Loop Circle at Devil's Pen Creek (SLA-006)*

Devil's Pen Creek is a large tributary to Slaughter Creek with a watershed area of 307 acres at the Weir Loop Circle crossing as shown on Figure 5-27. The existing drainage structure is a typical low water crossing consisting of two shallow 48" CMP at the low point of a relatively flat roadway as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| *2-Yr* | *10-Yr* | *25-Yr* | *100-Yr* | *2-Yr* | *10-Yr* | *25-Yr* | *100-Yr* |
| 254 | 662 | 913 | 1,335 | 275 | 719 | 991 | 1,450 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with an overtopping depth from the 100-year storm event of 1.73 feet. Weir Loop Circle is one of two access routes into a residential area including approximately 34 residences. One habitable structure may encroach the computed 100-year floodplain directly upstream of the crossing.

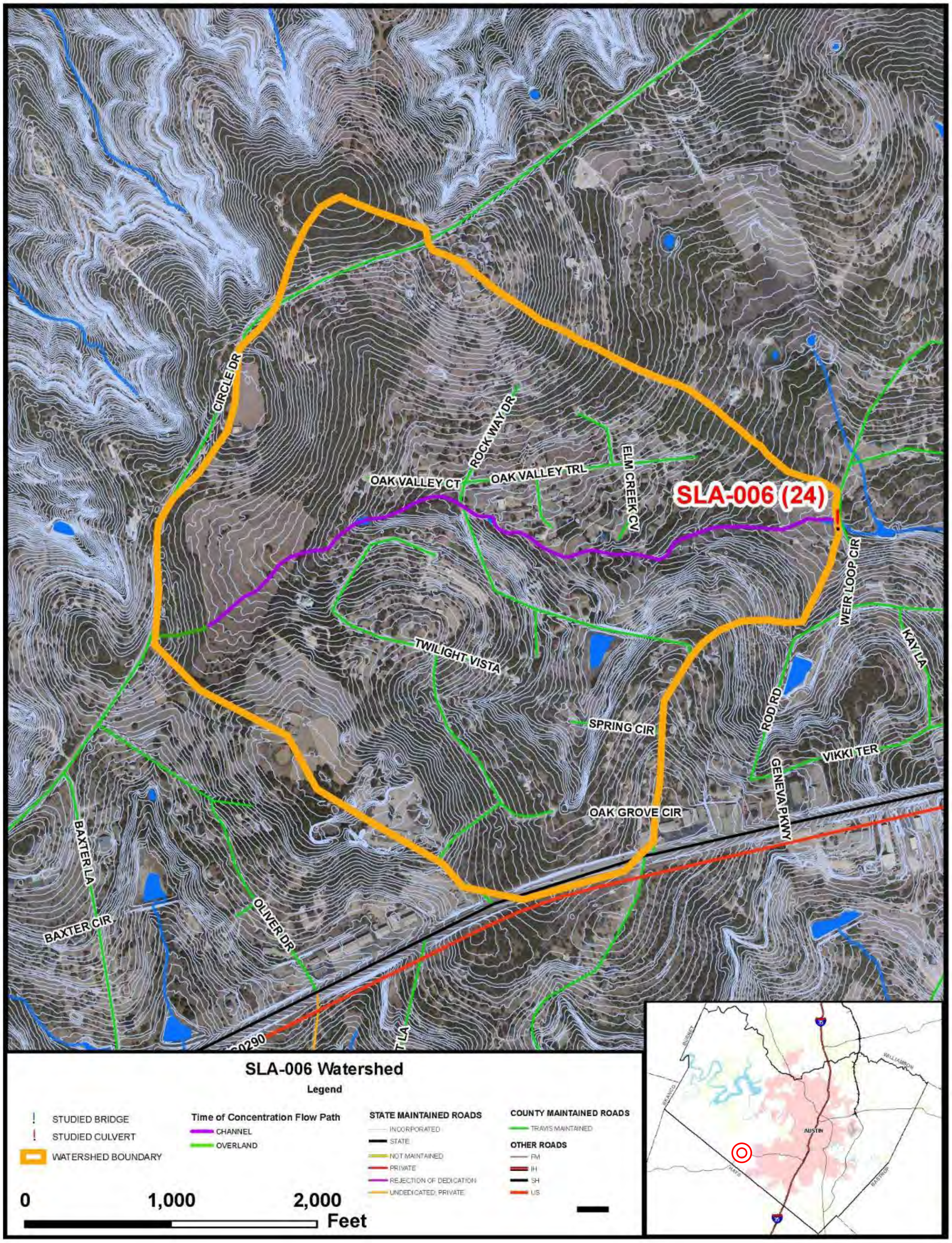



***Figure 5-27. Weir Loop Circle @ Devil's Pen Creek***

### *5.5.25 Tom Sassman Road at Maha Creek (MAH-003)*

Maha Creek is a large waterway with a watershed area of 1.4 square miles at the Tom Sassman Road crossing as shown on Figure 5-28. The existing drainage structure is a typical low water crossing consisting of five shallow 24" CMP at the low point of a relatively flat roadway as shown in the photos below.

The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 2,148 | 5,135 | 6,965 | 10,026 | 2,263 | 5,306 | 7,162 | 10,258 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with an average depth from the annual peak storm of 1.3 feet. Tom Sassman Road is one of two access routes into a rural residential area including approximately 30 residences.

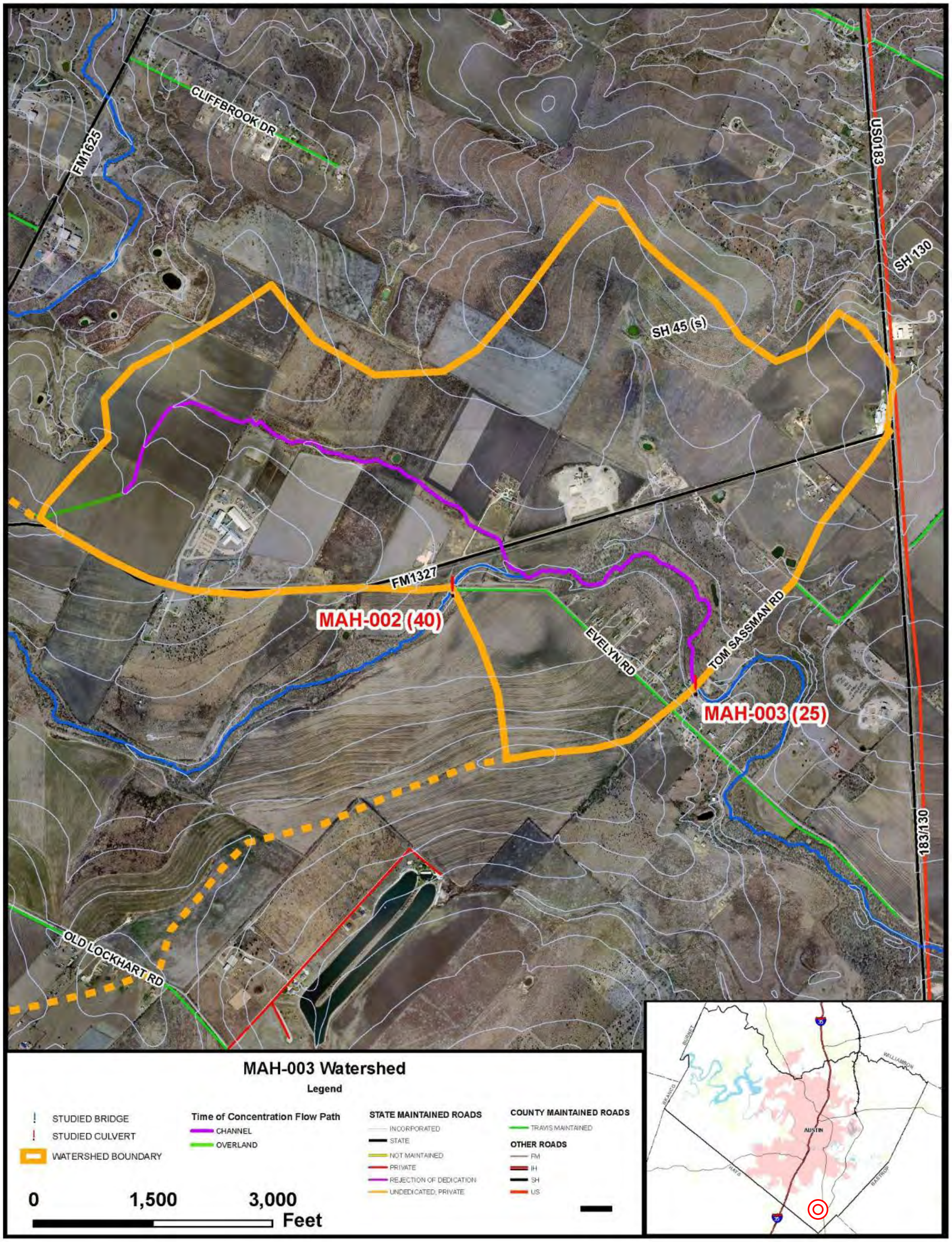
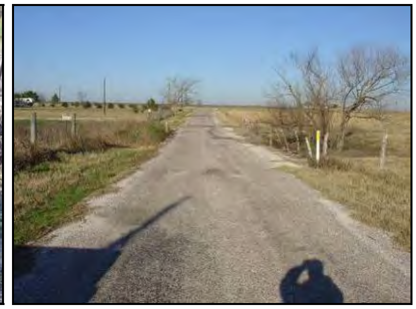



***Figure 5-28. Tom Sassman Road @ Maha Creek***

### *5.5.26 Felder Lane at Cottonwood Creek (CTW-003)*

Cottonwood Creek is a large waterway with a watershed area of 1.8 square miles at the Felder Lane crossing as shown on Figure 5-29. The existing drainage structure is a typical low water crossing consisting of one shallow 10'x3' concrete box culvert at the low point of a relatively flat roadway as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| *2-Yr* | *10-Yr* | *25-Yr* | *100-Yr* | *2-Yr* | *10-Yr* | *25-Yr* | *100-Yr* |
| 878 | 1,920 | 2,527 | 3,532 | 937 | 2,030 | 2,666 | 3,718 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with an average depth from the annual peak storm of 1.3 feet. Felder Lane is one of two access routes for approximately 5 residences in a rural area.

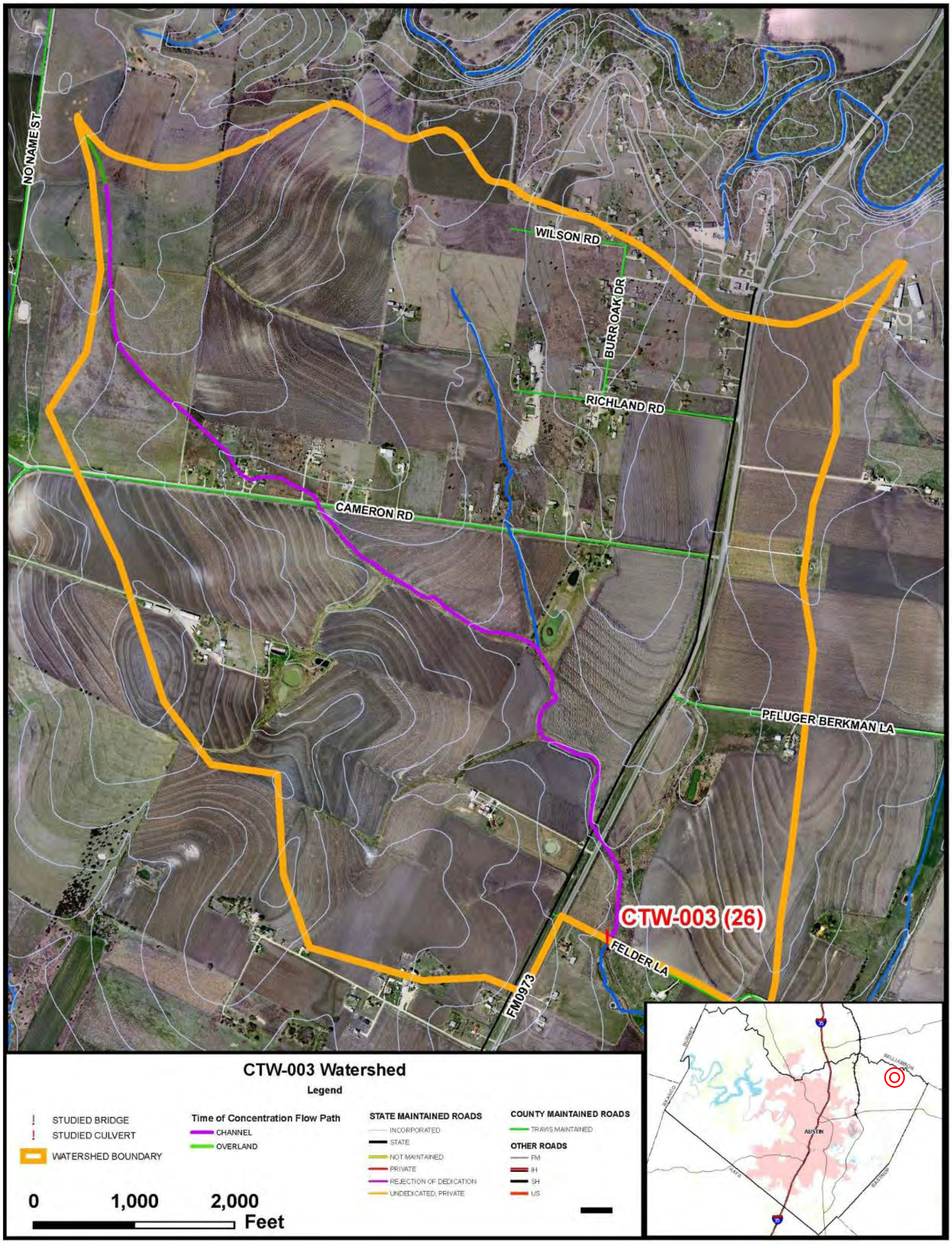



***Figure 5-29. Felder Lane @ Cottonwood Creek***

### *5.5.27 Parsons Road at Wilbarger Creek (WLB-009)*

Wilbarger Creek is a major waterway with a watershed area of 17.3 square miles at the Parsons Road crossing as shown on Figure 5-30. The existing drainage structure consists of two 13-ft concrete spans at the crossing on a relatively flat roadway as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 3,192 | 8,872 | 12,478 | 18,787 | 3,935 | 9,998 | 13,733 | 20,176 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with an average depth from the annual peak storm of 1.1 feet. A significant overtopping event from January of 2007 is shown in the photograph below. Parsons Road is one of two primary access routes for approximately 16 rural residences.

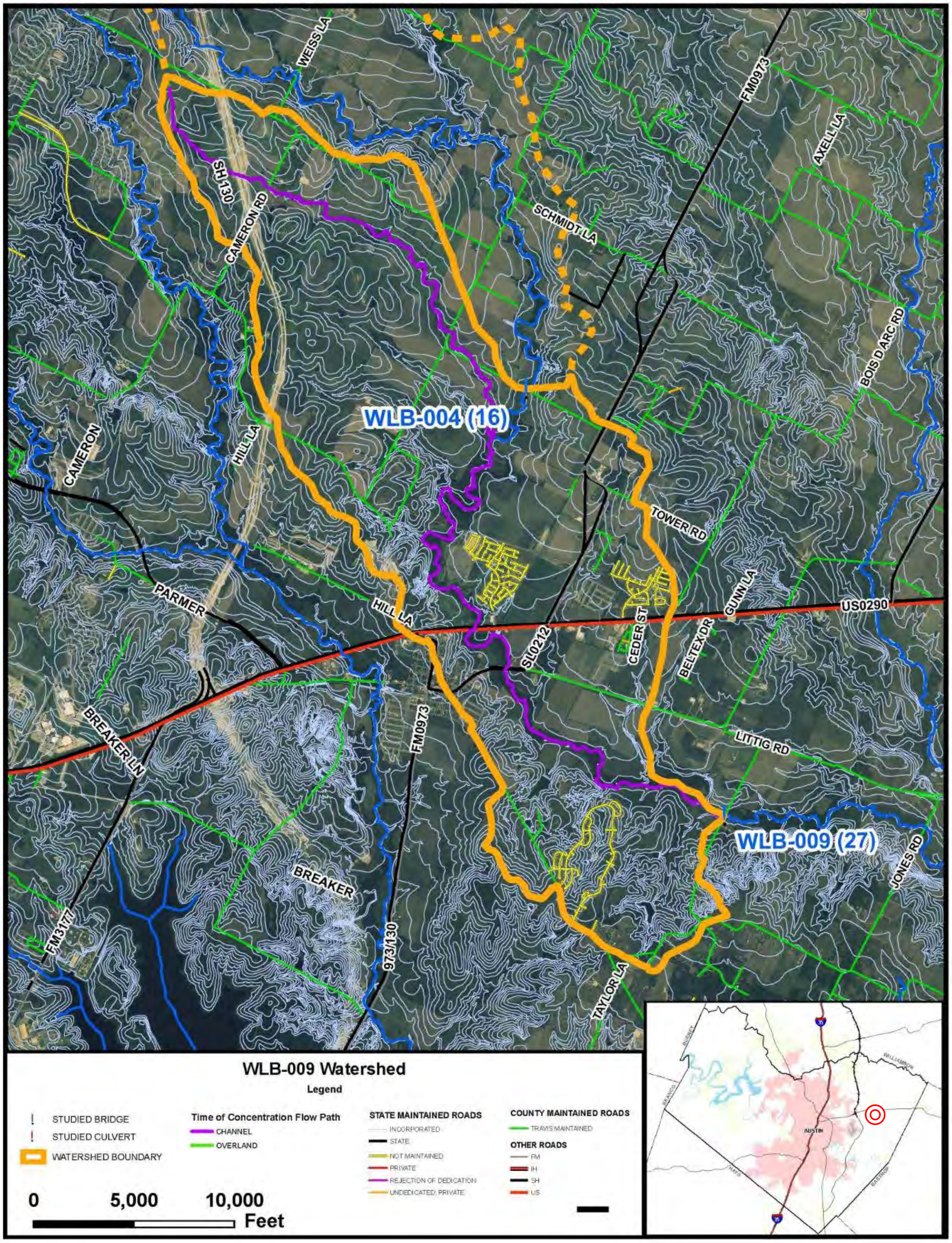



***Figure 5-30. Parsons Road @ Wilbarger Creek***

### *5.5.28 Westlake Drive at Unnamed Tributary to Lake Austin (WDT-001)*

The unnamed tributary is a minor tributary to Lake Austin with a watershed area of 98 acres at the Westlake Drive crossing as shown on Figure 5-31. The existing low water crossing has no drainage structure. All storm events flow over the roadway at the low point of the sag vertical curve as shown in the photos below.

The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 127 | 291 | 388 | 548 | 127 | 291 | 388 | 548 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with an average depth from the annual peak storm of 1.2 feet. Westlake Drive is one of two access routes into a residential area including over 100 residences.

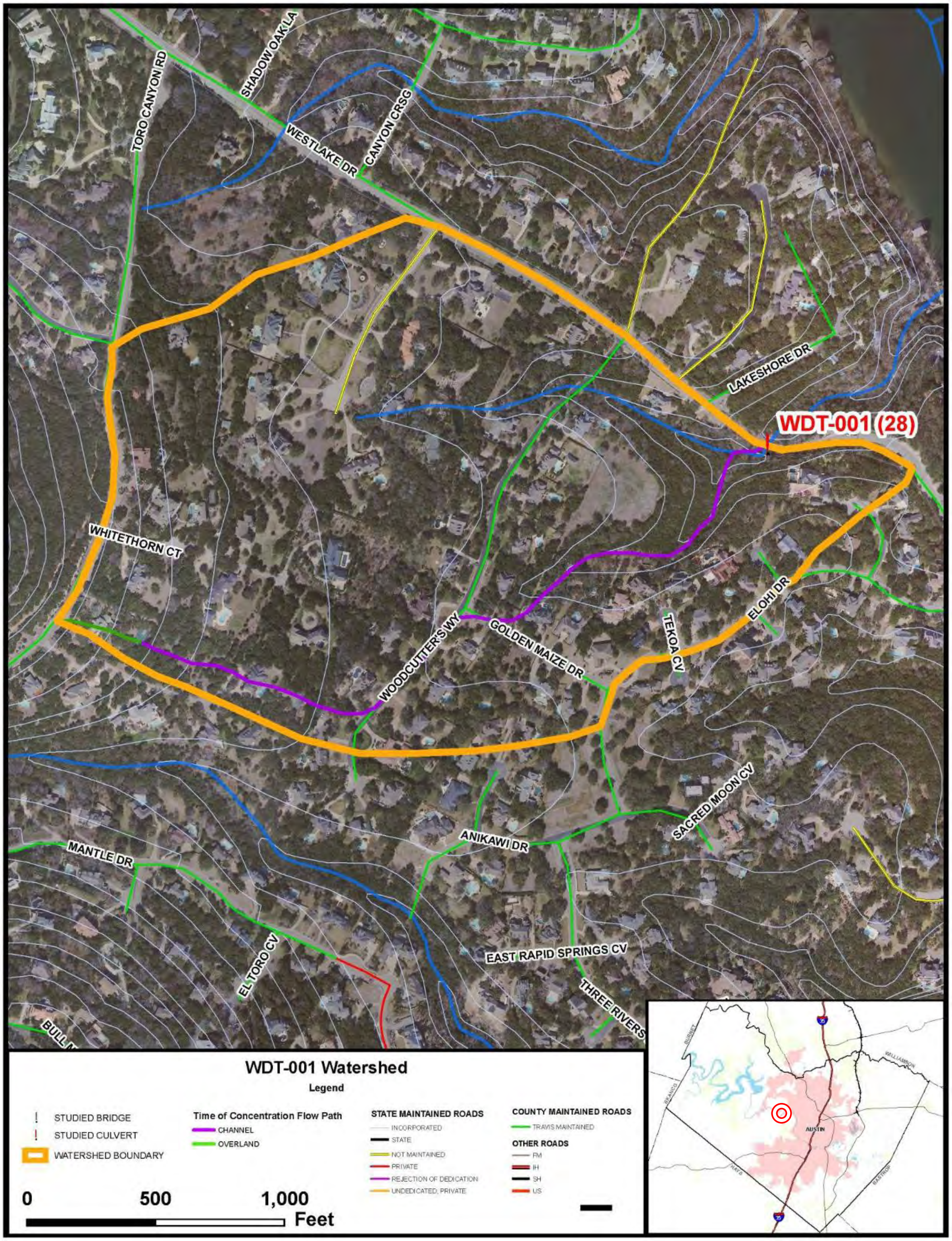



***Figure 5-31. Westlake Drive @ Unnamed Trib to Lake Austin***

### *5.5.29 Nameless Road at Nameless Hollow (LKT-007)*

Nameless Hollow is a large tributary to Big Sandy Creek with a watershed area of 217.55 acres at the Nameless Road crossing as shown on Figure 5-32. The existing low water crossing has no drainage structure. All storm events flow over the roadway at the low point of the sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 277 | 693 | 944 | 1,365 | 298 | 741 | 1,008 | 1,455 |

This low water crossing experiences frequent and severe overtopping as shown in Table 4.2 and Appendix B, with an average depth from the annual peak storm of 1.1 feet. Nameless Road is one of two primary access routes for a rural neighborhood of over 200 residences.

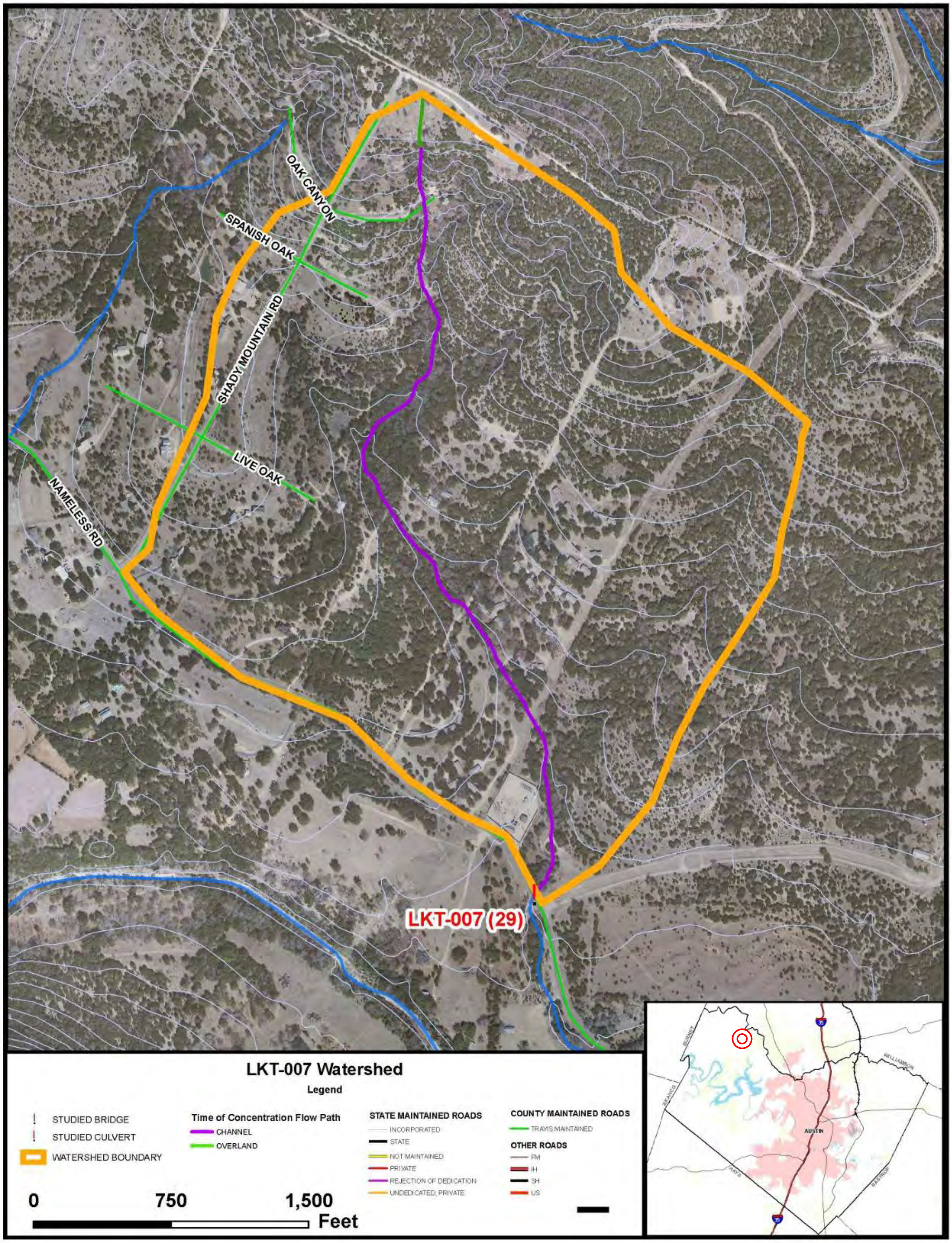
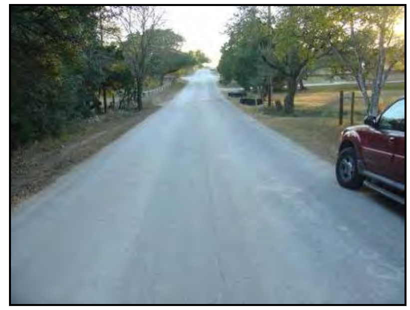



***Figure 5-32.  Nameless Road @ Nameless Hollow***

### *5.5.30 Ledgestone Terrace at Unnamed Tributary to Pen Creek (SLA-007)*

The unnamed tributary to Pen Creek is a minor waterway with a watershed area of 69.10 acres at the Ledgestone Terrace crossing as shown on Figure 5-33. The existing drainage structure is a typical low water crossing consisting of one shallow 24” RCP at the bottom of a sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 77 | 203 | 279 | 409 | 87 | 219 | 298 | 432 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with an overtopping depth from the 100-year storm event of 1.41 feet. An overtopping event from December of 2007 is shown in the photograph below. Ledgestone Terrace is also a single access way into a neighborhood including over 50 residences.

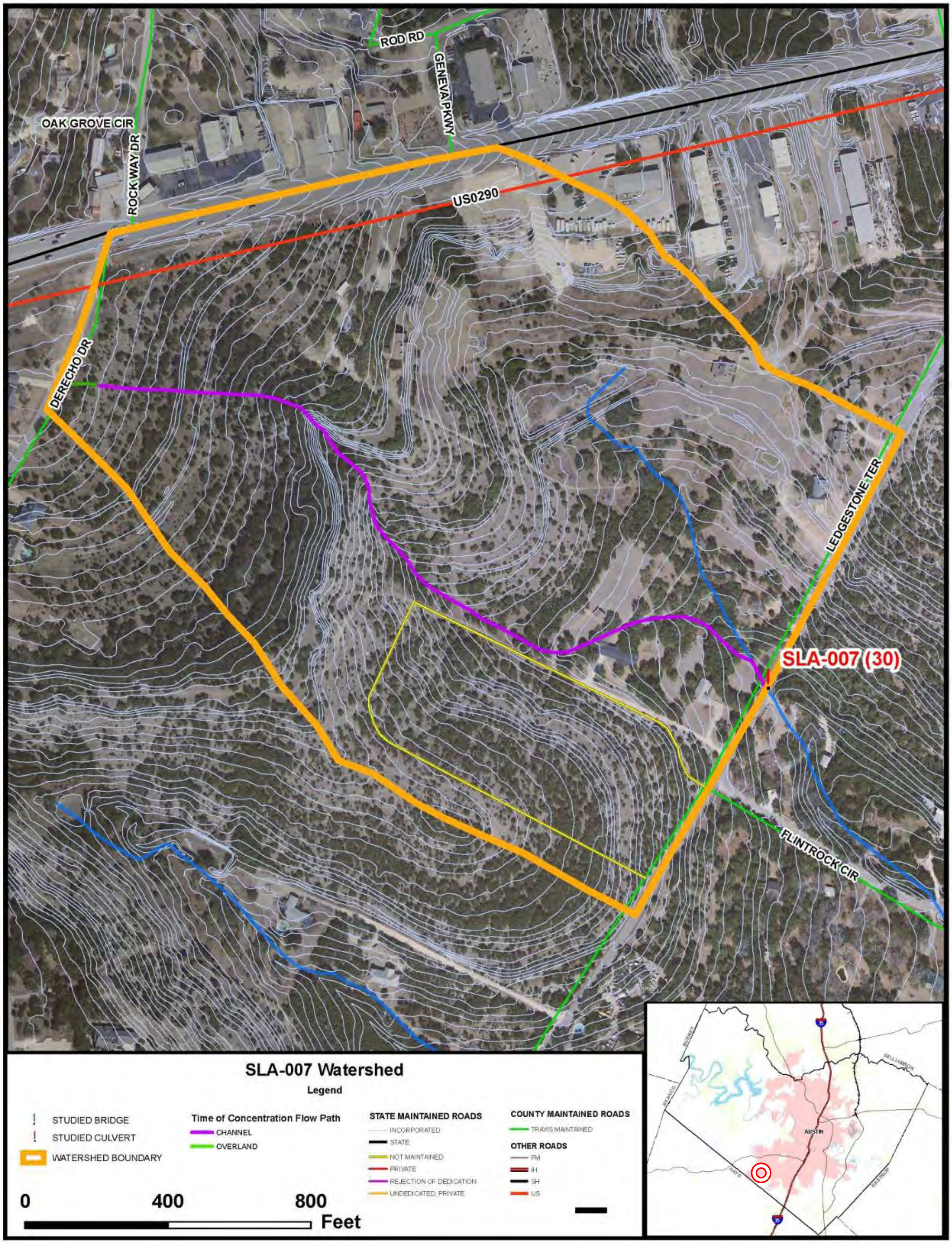



***Figure 5-33. Ledgestone Terrace @ Unnamed Trib to Pen Creek***

### 5.5.31 Wild Basin Street at Unnamed Tributary to Bee Creek (BEE-001)

The unnamed tributary to Bee Creek is an intermediate waterway with a watershed area of 452.35 acres at the Wild Basin Street crossing as shown on Figure 5-34. The existing drainage structure consists of three shallow 84” CMP at the low point of a relatively flat roadway as shown in the photos below.

The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 447 | 1,117 | 1,521 | 2,199 | 447 | 1,117 | 1,521 | 2,199 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with an overtopping depth from the 100-year storm event of 1.43 feet. Wild Basin Street is a single access way to approximately 15 residences.

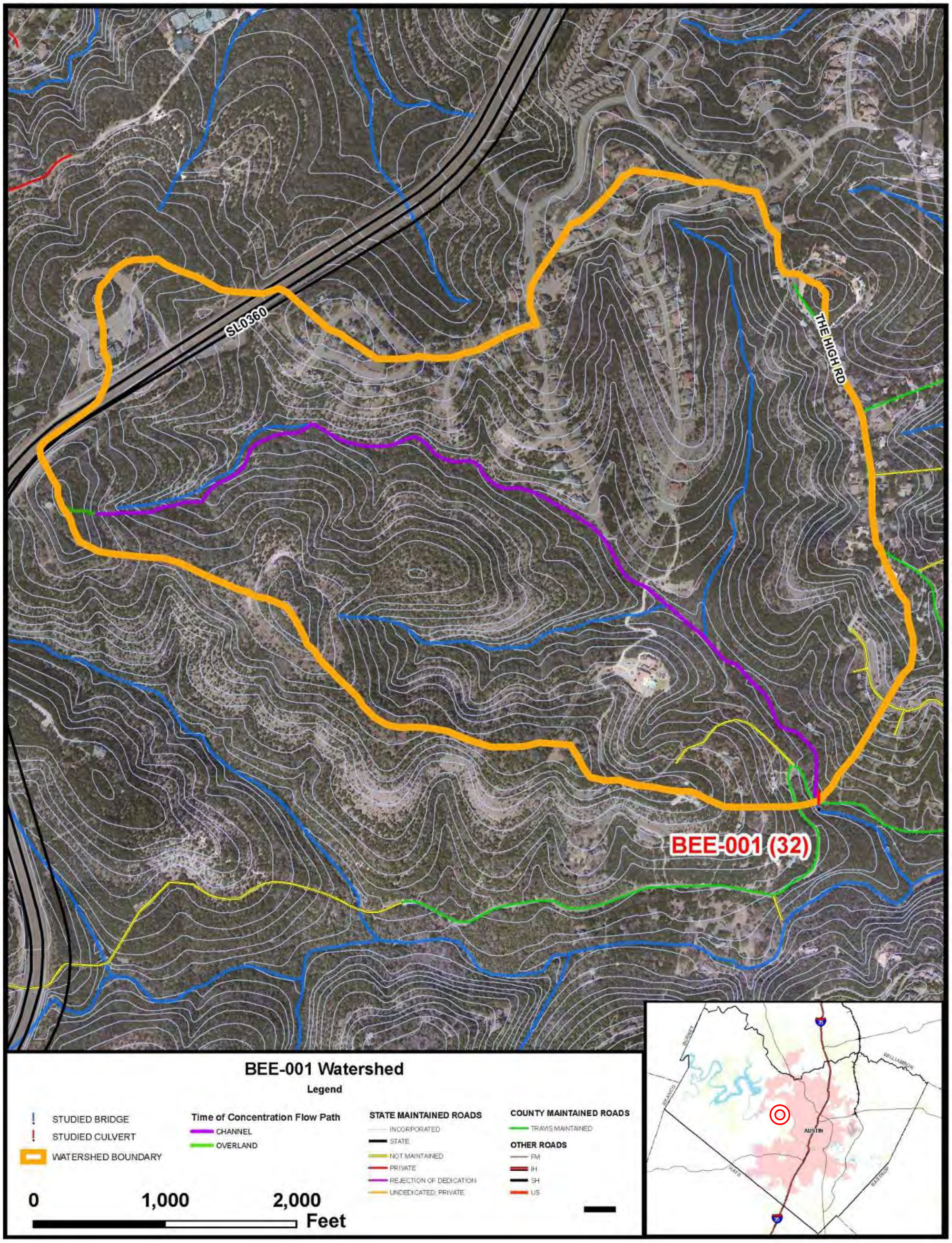



***Figure 5-34. Wild Basin Street @ Unnamed Trib to Bee Creek***

### *5.5.32 Caldwell Lane at River Timber Drive (COL-001)*

The watershed area at the low point on the curve between Caldwell Lane and River Timber Drive is 47.48 acres as shown on Figure 5-35. The existing low point has no drainage structure and has no outfall channel or pipe to drain runoff from the watershed. All storm events pond within the roadway and right-of-way at the low point of the sag vertical curve as shown in the photo below.

The following table provides a summary of computed discharges at the crossing:

| *Existing Conditions Peak Discharge (cfs)* | | | | *Ultimate Conditions Peak Discharge (cfs)* | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 10 | 51 | 82 | 138 | 17 | 68 | 102 | 165 |

This low water crossing experiences frequent and moderate flooding as shown in Table 4.2 and Appendix B. Caldwell Lane is a single access way to a residential area with over 150 residences.

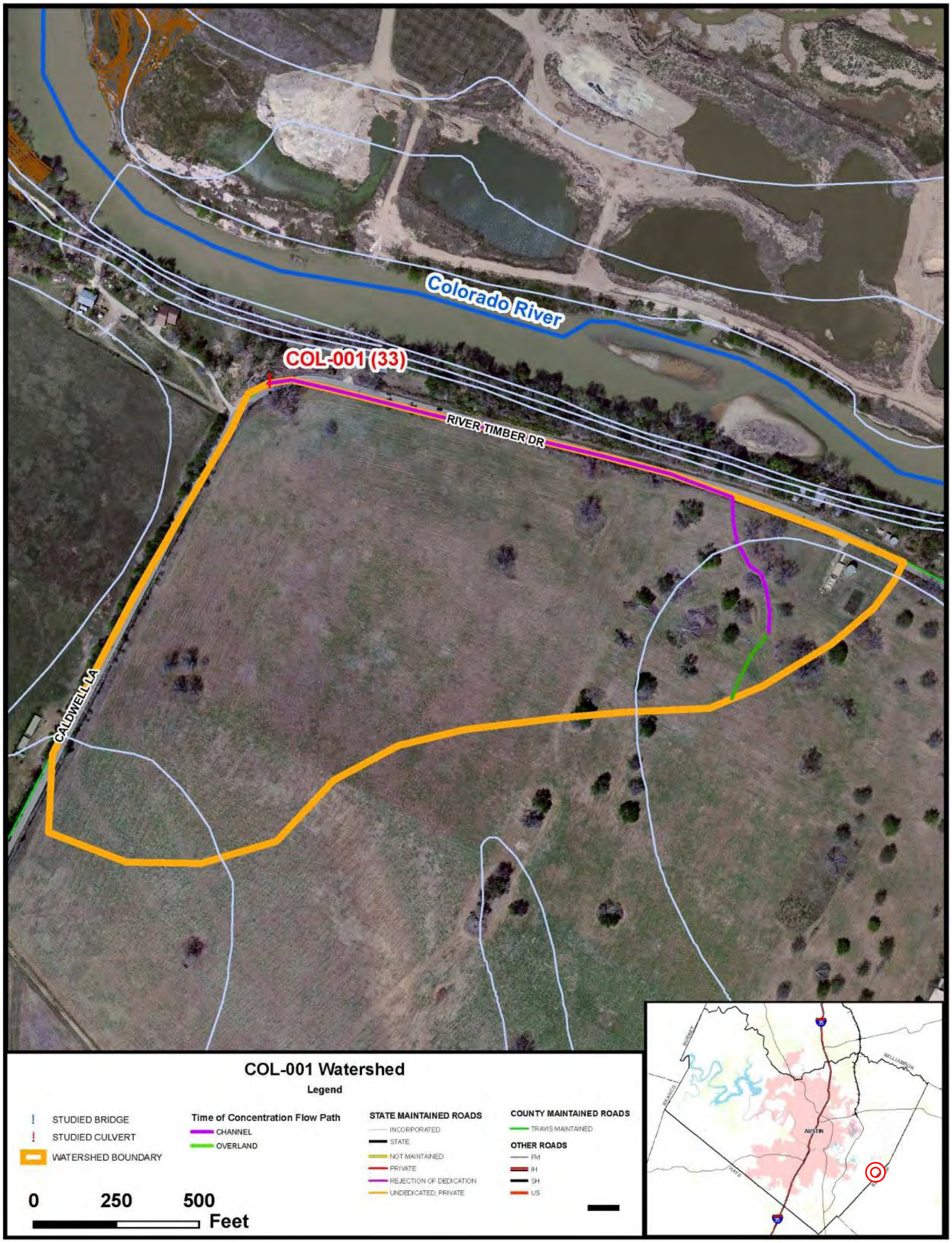



*Figure 5-35. Caldwell Ln @ River Timber Dr.*

### *5.5.33 Nameless Road at Unnamed Tributary to Big Sandy Creek (LKT-006)*

The unnamed tributary to Big Sandy Creek is a large tributary with a watershed area of 448.38 acres at the Nameless Road crossing as shown on Figure 5-36. The existing drainage structure is a typical low water crossing consisting of two shallow 36" RCP at the bottom of a sag vertical curve as shown in the photos below.

The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 472 | 1,155 | 1,566 | 2,254 | 508 | 1,228 | 1,660 | 2,380 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with an overtopping depth from the 100-year storm event of 2.68 feet. Nameless Road is one of two primary access routes for a rural neighborhood of over 200 residences.

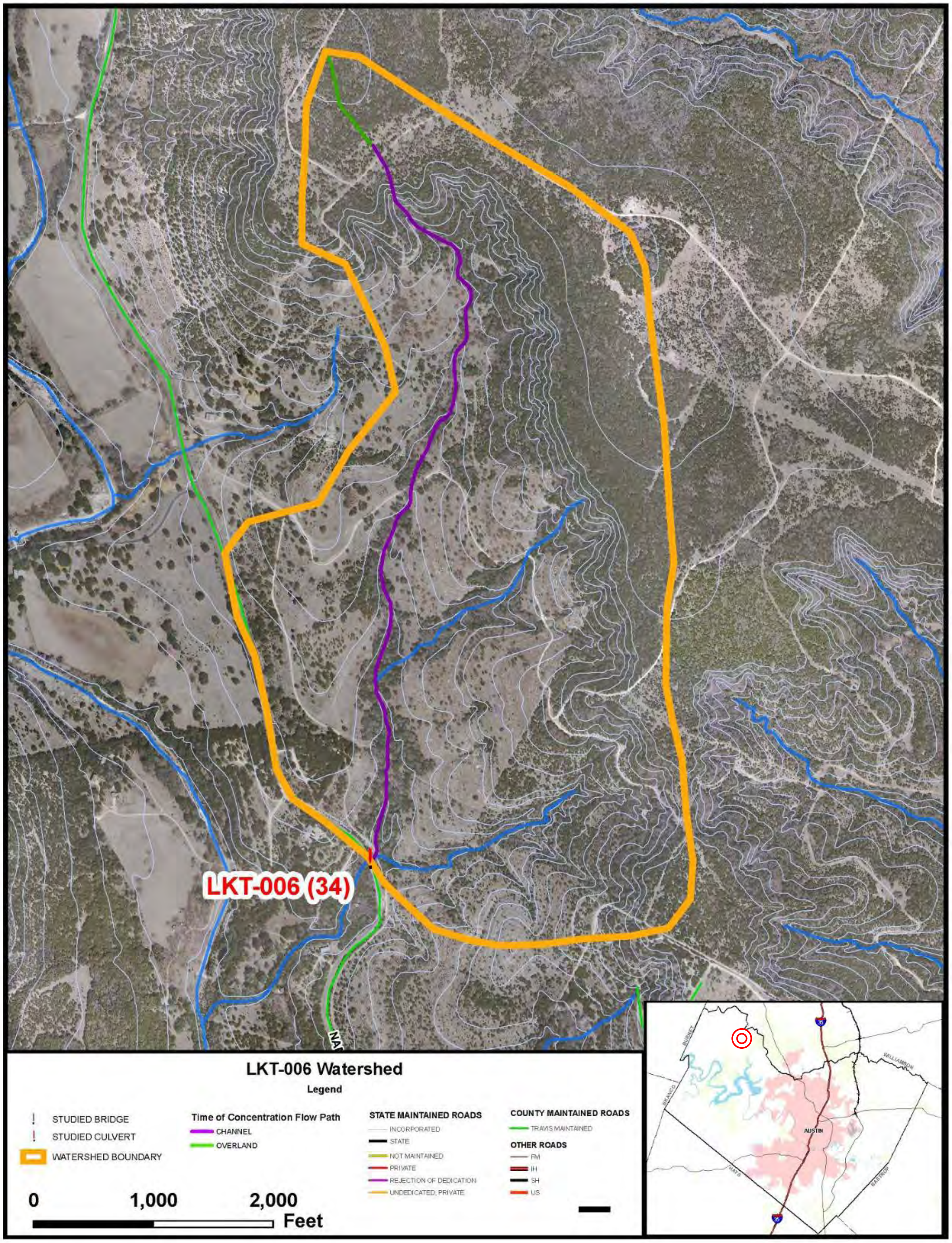



***Figure 5-36. Nameless Road @ Unnamed Trib to Big Sandy***

### *5.5.34 Weir Loop at Williamson Creek (WMS-001)*

Williamson Creek is a minor waterway with a watershed area of 191.12 acres at the Weir Loop crossing as shown on Figure 5-37. The existing drainage structure is a typical low water crossing consisting of one shallow 36" RCP culvert at the low point of a sag vertical curve as shown in the photos below.



The following table provides a summary of computed discharges at the crossing:

| ***Existing Conditions Peak Discharge (cfs)*** | | | | ***Ultimate Conditions Peak Discharge (cfs)*** | | | |
|---|---|---|---|---|---|---|---|
| ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** | ***2-Yr*** | ***10-Yr*** | ***25-Yr*** | ***100-Yr*** |
| 263 | 651 | 886 | 1,277 | 294 | 708 | 956 | 1,369 |

This low water crossing experiences frequent and moderate overtopping as shown in Table 4.2 and Appendix B, with an overtopping depth from the 100-year storm event of 1.32 feet. Weir Loop is a single access way to approximately 5 residences.

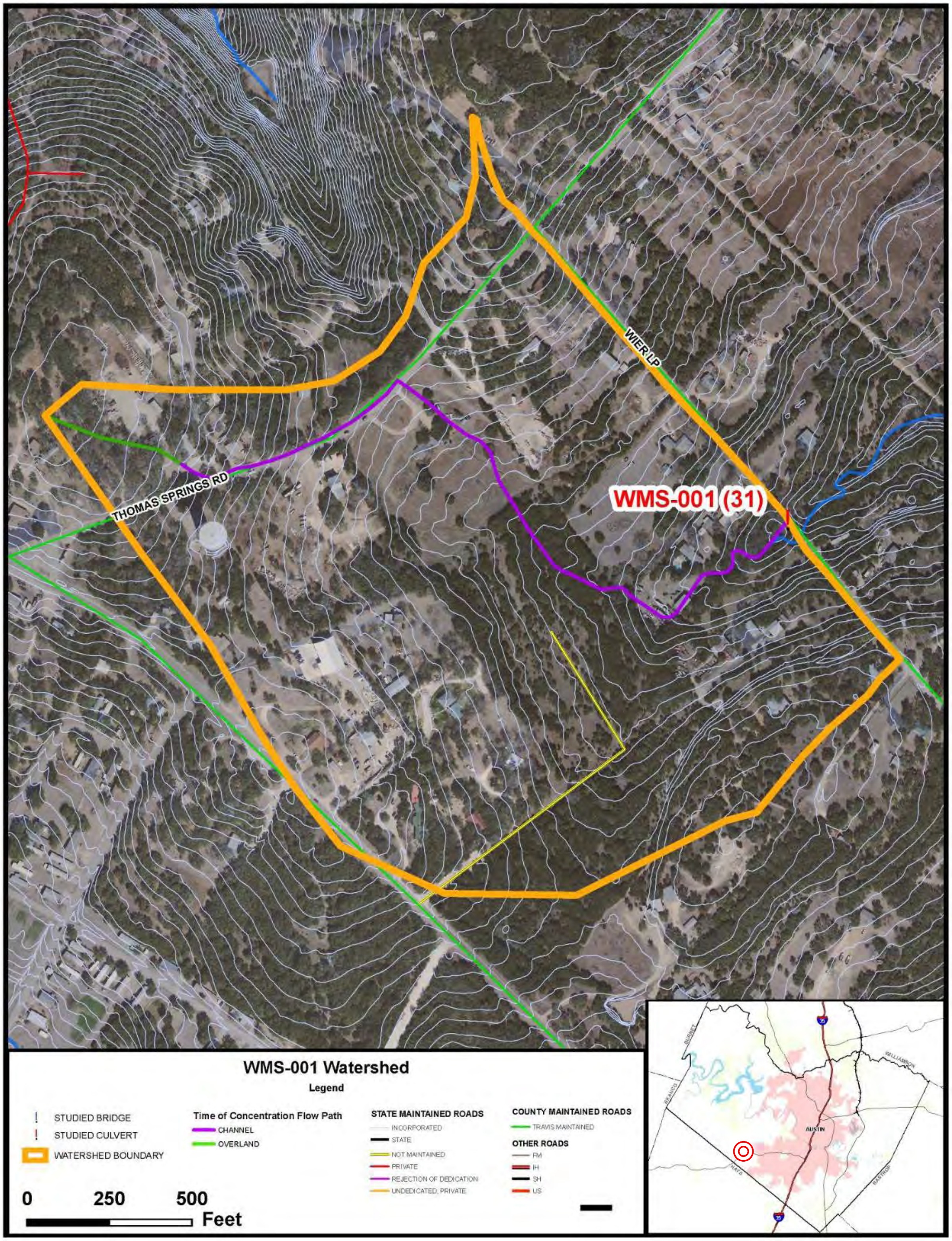



***Figure 5-37. Weir Loop @ Williamson Creek***

### *5.5.35 Swiss Alpine Village Subdivision (Maha Creek Watershed)*

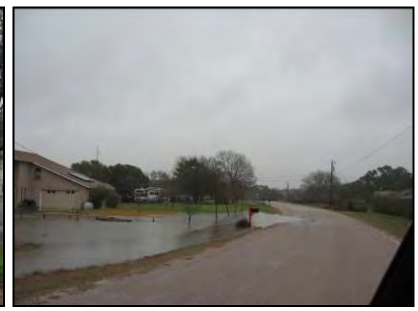
Swiss Alpine Village Subdivision experiences flooding from both major and minor watersheds. The subdivision is situated next to Maha Creek in eastern Travis County with a minor tributary coursing through the middle of the development as shown on the Swiss Alpine Existing Conditions Flooding Analysis map in Appendix B. Approximately 12 habitable structures are within the Maha Creek computed 100-year floodplain. Another 6 habitable structures are located within the computed 100-year floodplain for the minor tributary. The minor tributary also causes frequent and severe overtopping of three residential collector streets within the subdivision. Additionally, there are numerous instances of severe roadway and property flooding within the subdivision due to lack of roadside ditches, cross culverts, and driveway culverts. Some examples of minor flooding after a smaller storm event are shown in the photos below.




### *5.5.36 Arroyo Doble Subdivision (Onion Creek Watershed)*

Arroyo Doble Subdivision experiences flooding from both major and minor watersheds. The subdivision is situated at the confluence of Bear Creek and Onion Creek in southern Travis County as shown on the Arroyo Doble Existing Flood Areas maps in Appendix B. Flood mitigation plans were developed by the USACE and funding was approved by Travis County for acquiring approximately 4 habitable structures that were identified as being in the Onion Creek or Bear Creek 100-year floodplains by the previous USACE study mentioned in Section 1.4. There are numerous instances of severe roadway and property flooding within the subdivision due to the extremely flat terrain and lack of drainage infrastructure. Additionally, three roadway cross culverts experience frequent and severe overtopping within the subdivision. Some examples of flooding from a major storm event in January 2007 are shown in the photos below.











### *5.5.37 Twin Creek Park Subdivision (Onion Creek Watershed)*

Twin Creek Park Subdivision experiences flooding from mostly minor watersheds. The subdivision is adjacent to Arroyo Doble Subdivision and is also situated near the confluence of Bear Creek and Onion Creek as shown on the Twin Creek Park Existing Flood Areas map in Appendix B. There are numerous instances of severe roadway and property flooding within the subdivision due to the flat terrain and lack of drainage infrastructure. Additionally, two roadway cross culverts experience frequent and severe overtopping within the subdivision. Some examples of flooding from a major storm event in January 2007 are shown in the photos below.



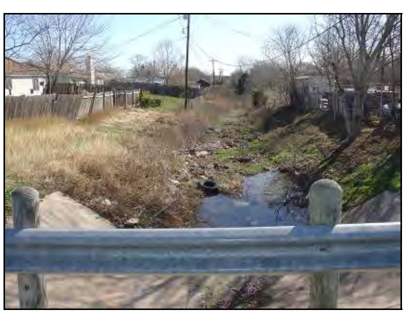






### *5.5.38 Thoroughbred Farms Subdivision (South Fork Watershed)*

Thoroughbred Farms Subdivision is situated next to the South Fork of Dry East Creek in eastern Travis County with a large manmade channel running through the middle of the development as shown on the Thoroughbred Farms Subdivision Existing Conditions Flooding Analysis map in Appendix B. Funding was approved by Travis County for acquiring a portion of approximately 12 habitable structures that were previously identified by the County as having repeated flood damage as mentioned in Section 1.4. The large manmade channel causes roadway and property flooding within the subdivision due to the lack of channel and culvert capacity. One habitable structure is within the computed 100-year floodplain of the large channel. Two roadway cross culverts experience frequent and moderate overtopping. Additionally, there are several areas of frequent roadway and property flooding within the subdivision due to lack of a street drainage system. Photos of the manmade channel, deficient culverts, and streets are shown below.

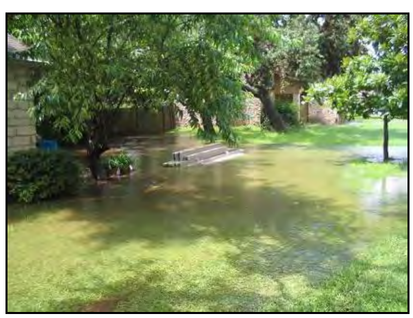
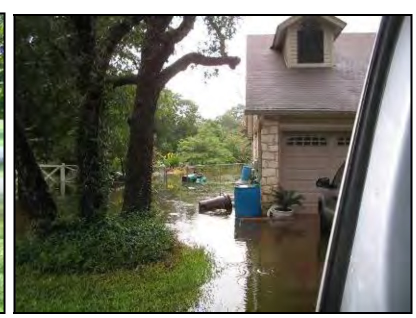


### *5.5.39 Southwest Territory Subdivision (Little Bear Creek Watershed)*

Southwest Territory Subdivision experiences flooding from mostly minor watersheds. The subdivision is situated near Little Bear Creek in southern Travis County with a minor tributary coursing through the middle of the development as shown on the Southwest Territory Subdivision Existing Conditions Flooding Analysis map in Appendix B. Approximately 10 habitable structures are within the computed 100-year floodplain of the minor tributary. The minor tributary also causes frequent overtopping of two residential streets within the subdivision. Additionally, there are numerous instances of frequent roadway and property flooding within the subdivision due to lack of roadside ditches, cross culverts, and driveway culverts. Some examples of flooding from previous storm events are shown in the photos below.





### *5.5.40 Austin Lake Estates Subdivision (Lake Austin Watershed)*

Austin Lake Estates is a large residential development in central Travis County that experiences flooding from mostly minor watersheds. The subdivision is adjacent to Lake Austin with several minor tributaries coursing through the development as shown on the Austin Lake Estates Existing Conditions Flooding Analysis maps in Appendix B. There are numerous instances of frequent roadway and property flooding within the subdivision due to lack of roadside ditches, cross culverts, and driveway culverts. Photos of some of the problem areas are shown below.





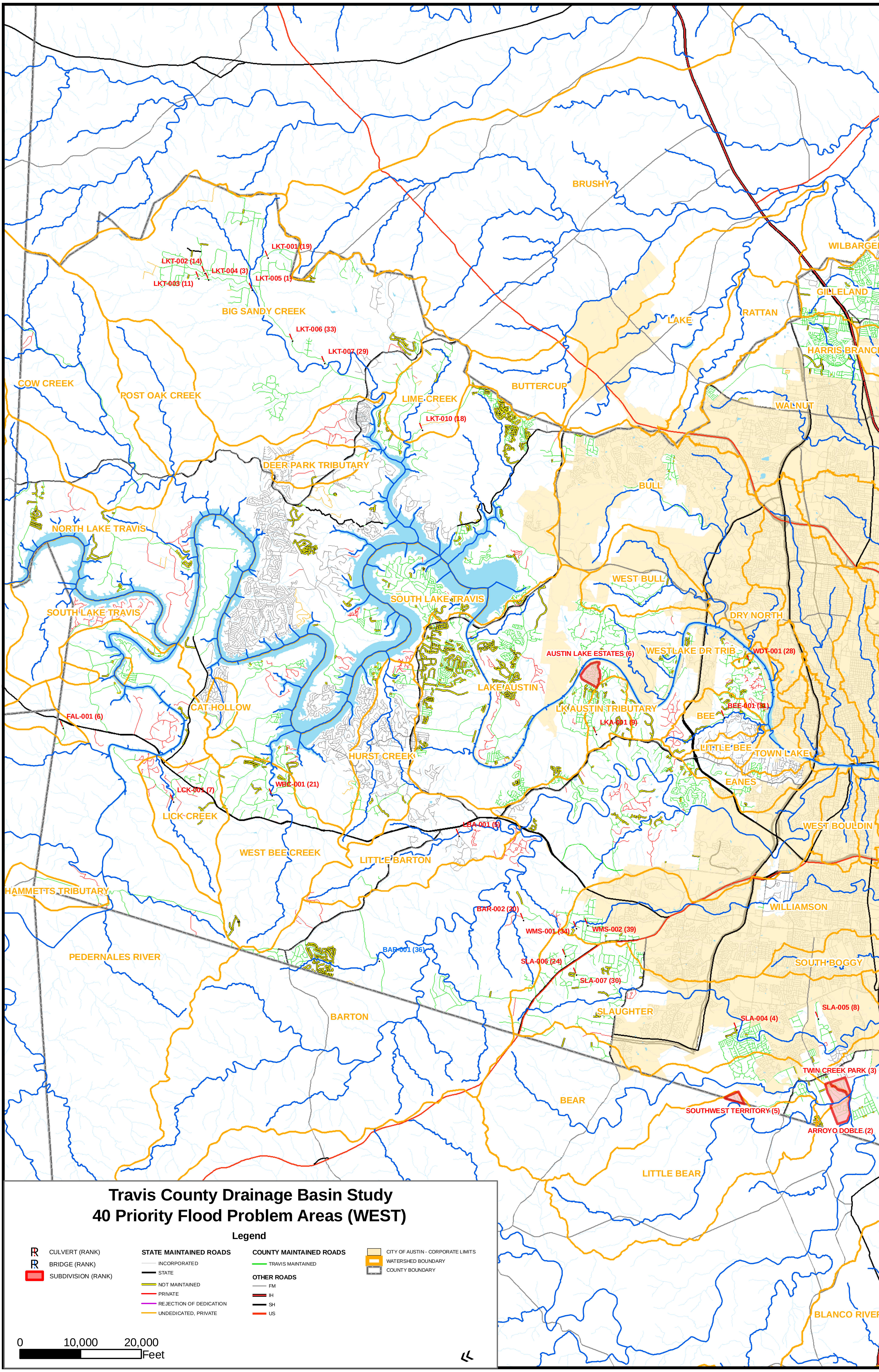


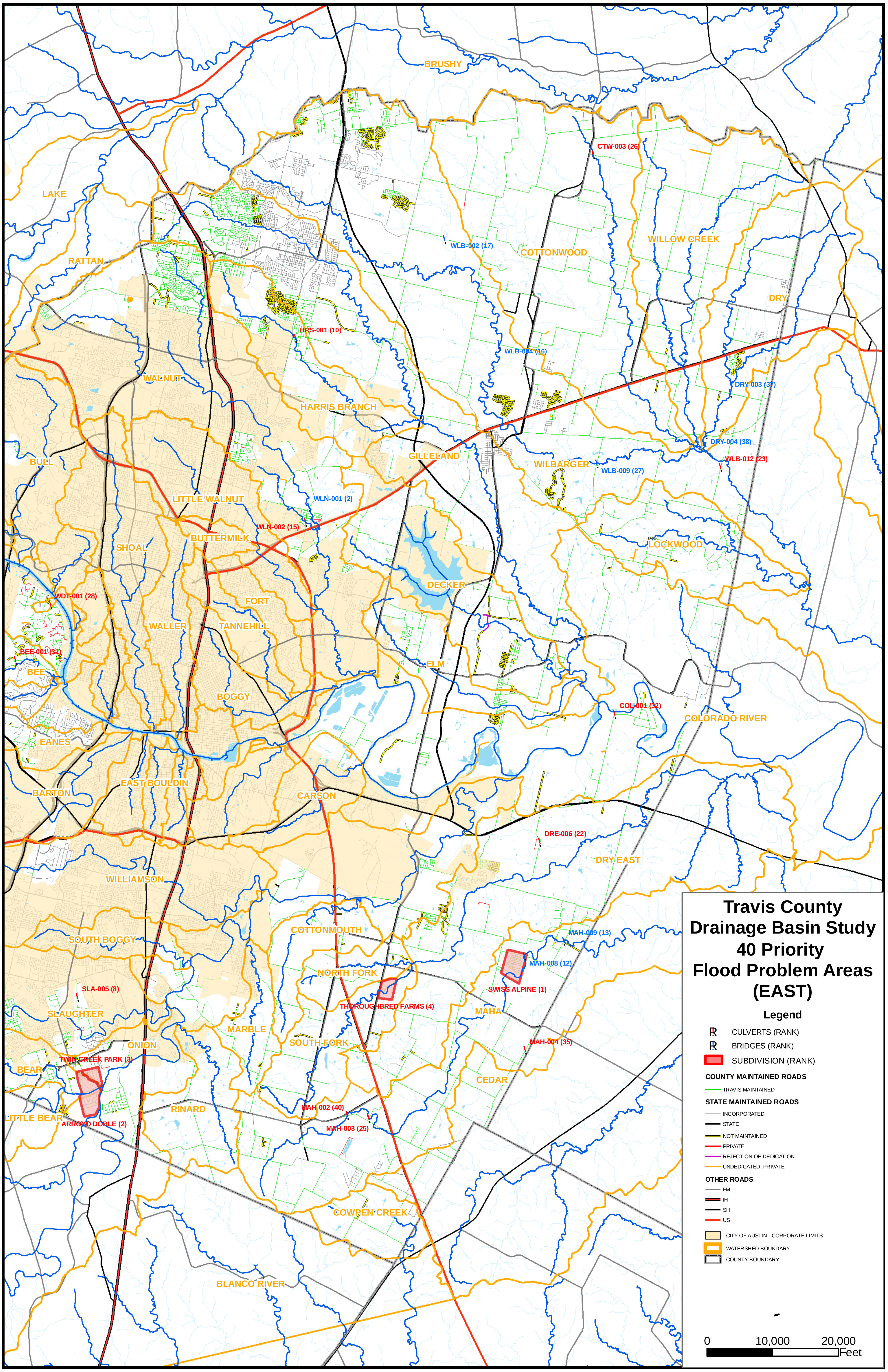







# Travis County Drainage Basin Study
# 40 Priority Flood Problem Areas (WEST)





Travis County
Drainage Basin Study
40 Priority
Flood Problem Areas
(EAST)
Legend
CULVERTS (RANK)
BRIDGES (RANK)
SUBDIVISION (RANK)
COUNTY MAINTAINED ROADS
TRAVIS MAINTAINED
STATE MAINTAINED ROADS
INCORPORATED
STATE
NOT MAINTAINED
PRIVATE
REJECTION OF DEDICATION
UNDEDICATED, PRIVATE
OTHER ROADS
FM
IH
SH
US
CITY OF AUSTIN - CORPORATE LIMITS
WATERSHED BOUNDARY
COUNTY BOUNDARY
0
10,000
20,000
Feet
BRUSHY
LAKE
RATTAN
CTW-003 (26)
WLB-002 (17)
COTTONWOOD
WILLOW CREEK
DRY
HRS-001 (10)
WLB-004 (16)
DRY-003 (37)
WALNUT
HARRIS BRANCH
DRY-004 (38)
WLB-012 (23)
GILLELAND
WILBARGER
WLB-009 (27)
BULL
LITTLE WALNUT
WLN-001 (2)
WLN-002 (15)
BUTTERMILK
SHOAL
LOCKWOOD
DECKER
WDT-001 (28)
FORT
WALLER
TANNEHILL
BEE-001 (31)
BEE
ELM
BOGGY
COL-001 (32)
COLORADO RIVER
EANES
EAST BOULDIN
BARTON
CARSON
DRE-006 (22)
DRY EAST
WILLIAMSON
COTTONMOUTH
MAH-009 (13)
SOUTH BOGGY
MAH-008 (12)
NORTH FORK
SLA-005 (8)
SWISS ALPINE (1)
THOROUGHBRED FARMS (4)
SLAUGHTER
MAHA
MARBLE
ONION
SOUTH FORK
MAH-004 (35)
TWIN CREEK PARK (3)
BEAR
CEDAR
RINARD
LITTLE BEAR
MAH-002 (40)
ARROYO DOBLE (2)
MAH-003 (25)
COWPEN CREEK
BLANCO RIVER

# Section 6
# Flood Mitigation Alternatives Analysis

Conceptual flood mitigation alternatives and capital cost estimates were developed for the top 40 priority problem areas determined from the final ranking process described in the previous section. The following sections describe the alternatives considered and the basis for estimating capital costs for each alternative plan.

## 6.1 Evaluation of Flood Mitigation Measures

In developing flood mitigation alternatives, a full range of structural and nonstructural alternatives are considered. Structural alternatives are those measures constructed to reduce, contain, or divert the flow of water from flood prone areas and are intended to reduce or eliminate damage to property, potential for loss of life, and economic loss. Structural alternatives include measures such as bridge and culvert improvements, channel improvements, storm sewer systems, detention reservoirs, levees, and diversions of floodwaters. Nonstructural alternatives are those that propose management of floodplain lands by the removal or exclusion of damageable properties (residences, businesses, etc.) from flood prone areas. These measures do not affect the frequency or level of flooding within a floodplain, but affect activities within the floodplain. Nonstructural alternatives include regulatory measures, floodplain evacuation (acquisition), relocation, flood forecasting, and floodproofing. Below is a description of each alternative that was considered.

### 6.1.1 Structural Alternatives

#### 6.1.1.1 Bridge and Culvert Improvements

Bridges and culverts span rivers, streams, and channels to convey vehicular traffic. In many cases throughout the County, the structures are capable of passing low flows, but they may have inadequate opening area to convey higher discharges during flood conditions. Bridges and culverts that have insufficient area to convey higher flows tend to overtop frequently, preventing the passage of vehicles during high flow times and produce excess backwater that may result in flooding of upstream properties. Bridges and culverts that overtop frequently pose a significant threat to public safety as most flood related deaths occur at these types of crossings. Enlargement of bridges and culverts was considered in order to improve the hydraulic capacity of the structure, reduce the frequency and depth of overtopping, and reduce flooding of upstream properties.

Bridge and culvert improvements can usually be accomplished within existing right-of-way or easements and can potentially be performed by County workforces. This alternative was considered most applicable for many of the high priority problem areas.

#### 6.1.1.2 Channel Improvements

Channel improvements generally lower flood levels by improving the hydraulic efficiency of a stream or roadside channel by enlarging the channel, straightening the channel, reducing the channel friction by smoothing the contours and/or lining of the channel banks, and removing obstructions. The increase in channel velocity permits a given flow rate to be passed through a channel reach at a lower water surface elevation. The cross-sectional area of the channel is usually increased, which contributes to the lowering of the water surface elevation. Channel improvements generally reduce the area flooded for all flow rates, even those in excess of the design capacity. Evaluation of channel improvements usually includes different channel sizes and surface types, such as grass-lined or concrete-lined channels.

Channel improvements for existing conveyance channels within minor watersheds were considered. Channel improvements in the form of roadside ditches and conveyance channels were applicable within subdivision areas flooded by flows from minor watersheds.

#### 6.1.1.3 Storm Sewer Improvements

Street flooding is a common occurrence in many subdivision areas in the County. Excessive street flow has caused flooding of residential and commercial structures, interruption of traffic flow, and damage to pavement. In some cases, the only feasible solution for reducing street flow in subdivision areas is by installing storm sewer systems to collect runoff and convey it underground to a receiving stream. This is due to existing curb and gutter systems, lack of right-of-way, and the density of utilities and homes generally associated with urban areas that restrict the construction of open channels and ditches.

This alternative was considered as part of the solution for problem areas within minor watersheds. Storm sewer improvements can usually be accomplished within existing right-of-way or easements and can be used for improving street flow and diverting stormwater around problem areas.

#### *6.1.1.4 Stormwater Detention*

Stormwater detention reservoirs are a means of controlling flooding by temporarily impounding upstream floodwaters during significant storm events. The impounded floodwaters are released at a controlled rate to reduce peak flows downstream and corresponding flood levels. Stormwater detention requires the availability of an upstream impoundment site capable of providing sufficient storage. Stormwater detention can include major impoundments for control of runoff on a regional scale and smaller detention structures that reduce runoff rates from smaller watersheds within developed areas.

Smaller stormwater detention facilities were considered applicable as a potential part of the solution for problem areas within minor watersheds where existing land is available and topography is favorable.

#### *6.1.1.5 Levees*

Levees confine out-of-bank flows to areas along rivers and streams to prevent flood damages to properties located in the natural flood plain. The confinement of floodwaters using levees considerably alters the characteristics of flood flows. Reduction of natural valley storage capacity in the flood plain can increase peak discharges for a given flood and increase flood damages downstream of a levee. Land must be reserved behind the levees for ponding areas, and impounded water must be retained or pumped over the levee. Levees are most applicable where the flood plain is wide and development is located a considerable distance from the channel. Levees can cause catastrophic damage if overtopped by a flood greater than the design flood. Therefore, the design flood for levees is typically the 100-year flood, with additional freeboard to provide for a low risk of overtopping.

#### *6.1.1.6 Stormwater Diversion*

Diversion of floodwaters to an adjacent stream or channel or around an area to be protected may be economically viable when the receiving stream or conveyance system has adequate capacity to carry the additional flows. For large streams, a typical diversion channel or tunnel would cross watershed boundaries which requires deep excavation cuts in order to cross over the higher elevation at a watershed divide. Deep excavation cuts and associated relocation of associated utilities and roadways usually requires diversions to be over a short distance in order to be economically feasible. For minor channels and conveyance systems, diversion of floodwaters typically involves constructing smaller channels or storm sewers over short distances and upgrading existing conveyance systems. Minor stormwater diversions were considered applicable for some minor watershed areas.

### *6.1.2 Nonstructural Alternatives*

#### *6.1.2.1 Regulatory Measures*

Adoption of regulations by local governments provide legal measures to control development in flood prone areas and to prevent the occurrence of future drainage related problems. Regulation of flood prone land ensures the property will be properly used in the best interest of public health, safety and welfare. However, such regulations offer no relief for existing development.

Travis County currently has floodplain management regulations (Chapter 64 of the Travis County Code) and drainage design regulations (Chapter 82 of the Travis County Code) in place for new development. Travis County is a participant in the National Flood Insurance Program (NFIP), and floodplain management regulations have been previously adopted in accordance with NFIP requirements. The County is currently proposing revisions to its current floodplain management regulations to include more comprehensive floodplain management regulations based on the recent re-study of Travis County floodplains by FEMA. The County also adopted Standards for Construction of Streets and Drainage in Subdivisions in August 1997 for regulation of drainage standards in new developments within unincorporated portions of Travis County. The County is currently proposing revisions to the drainage standards to provide more comprehensive requirements and conformance with City of Austin drainage standards. Given the existing regulations in place and the comprehensive revisions proposed, additional regulatory measures were not considered.

#### *6.1.2.2 Flood Plain Evacuation (Acquisition)*

Permanent evacuation of developed flood plain areas is one method to eliminate flood damage potential. This alternative includes the acquisition of privately-owned lands, residences, businesses, and other improvements. The improvements would be removed, the population relocated to areas outside the flood zone, and the land committed to parks, greenbelt areas, or other uses consistent with periodic flooding.

Evacuation and relocation alternatives are generally most cost effective in areas that flood frequently. If economic feasibility cannot be demonstrated in these areas, then it is typically not feasible in areas of less frequent flooding.

#### *6.1.2.3 Flood Forecasting*

Flood forecasts and temporary evacuation involves the determination of imminent flooding, implementation of a plan to warn the public, and organization of assistance in evacuating persons and certain personal property. Notification of impending flooding can be made by radio, siren, individual notification, or by more elaborate means such as a remote sensor to detect rising water. While this alternative does not substantially reduce flood damages, it does prevent loss of life and may prevent damage to some portable property, including vehicles, by early warning. Flood forecasting can lead to a sense of low concern if warnings are issued and only minor flooding or no damage occurs. Flood warnings should be a part of any plan, although consideration of forecasting beyond the present level was not considered further, due to the short warning time that exists with flash flooding in many of the watersheds studied.

#### *6.1.2.4 Floodproofing*

Floodproofing generally consists of providing watertight coverings for door and window openings of habitable structures, raising structures in place, raising access roads and escape routes, constructing levees and floodwalls around individual buildings or groups of buildings, and waterproofing of walls of structures. Floodproofing is more easily applied to new construction and more applicable where flooding is of short duration, low velocity, infrequent, and of shallow depths. Floodproofing is also appropriate for locations where structural flood protection is not feasible.

Implementation of floodproofing for most structures in the study area would require significant and costly modifications to existing structures. Some floodproofing in the form of raising roadways above flood levels to improve emergency access was considered applicable.

### *6.2 Design Criteria*

In developing flood mitigation alternatives for each problem area, at least one alternative was developed to meet the full requirements of current Travis County design criteria, and at least one other alternative was developed to a more feasible or practical level of design, with the 2-year design storm typically set as the minimum standard. The current Travis County requirements and design criteria are described below.

Travis County previously adopted the Standards for Construction of Streets and Drainage in Subdivisions (Chapter 82 of the Travis County Code) and the Travis County Regulations for Floodplain Management (Chapter 64 of the Travis County Code). Regulations within Chapter 82 were originally adopted in 1980 with subsequent revisions adopted in 1984 and 1997. Section 82.207, Stormwater, Drainage, and Floodplains, was developed for use as a guidance document for designing and evaluating drainage facilities for development within the County's jurisdiction. Paragraph (b) of Section 82.207 states that "Stormwater data and calculations and design of stormwater drainage facilities and controls shall meet the specifications of the City of Austin Drainage Criteria Manual". Therefore, the City of Austin Drainage Criteria Manual (DCM) was used in developing flood mitigation alternatives. The DCM provides general drainage design policies and specific design criteria for different types of drainage facilities. General drainage design policies specific to developing flood mitigation alternatives for this study include the following:

- The public drainage system shall be designed to intercept, contain and transport all runoff from the 25-year frequency storm. (DCM, Section 1.2.2 B)
- The public drainage system shall be designed to convey those flows from greater than the 25 year frequency storm up to and including the 100-year frequency storm within defined public rights of way or drainage easements. (DCM, Section 1.2.2 C)

Impacts to existing floodplain elevations were also considered when developing flood mitigation alternatives. The current floodplain management regulations within Chapter 64 of the Travis County Code were adopted by the County in 1987. One of the primary purposes for adopting the regulations was to minimize hazards to life and property by regulating encroachment in the flood plains. The regulations were in compliance with then-current minimum NFIP requirements in accordance with 44 Code of Federal Regulations (CFR). Part 60.3 of 44 CFR allows for a maximum of one foot of rise to the base flood elevation (100-year floodplain elevation) caused by new construction, substantial improvements, or other development (including fill) when placed within a community's special flood hazard area (SFHA) Zones A1-30 and AE as shown on the community Flood Rate Insurance Maps (FIRM). Zones A1-30 and AE represent SFHAs with base flood elevations determined by detailed methods. The majority of the high priority problem areas identified in this study do not fall within a FEMA Zone A1-30 or Zone AE. Many of the problem areas are located within a SFHA Zone A which represents an approximate area of inundation by the 100-year flood. Many problem areas do not fall within any FEMA regulated SFHAs. Based on discussions with the County's floodplain management staff, the preferred floodplain management approach for this study was to provide flood mitigation alternatives with no adverse impact to existing floodplains. Thus, structural flood control alternatives were developed to cause zero rise to existing floodplains where feasible.

The following sections detail the drainage criteria specific to the facilities analyzed as a part of this study, which include culverts, bridges, open channels, storm sewer systems, and street drainage systems.

### *6.2.1 Bridges and Culverts*

The function of a bridge or culvert is to safely pass flow under a roadway, railroad, or other feature allowing safe passage of traffic over the waterway, and without causing damage to the structure or to property located upstream and downstream of the structure. With the intent of maintaining emergency access, the DCM states that for bridges and culverts in residential streets, runoff from the 100 year frequency flow shall not produce a headwater elevation at the roadway greater than either 12 inches above the roadway crown elevation or any top of upstream curb elevation, whichever is lower. For bridges and culverts in streets other than a residential street, runoff from the 100 year frequency storm shall not produce a headwater elevation at the roadway greater than 6 inches above the roadway crown elevation or 6 inches above any top of upstream curb elevation, whichever is lower. The DCM also provides criteria for erosion protection upstream and downstream of culverts based on culvert entrance and exit velocities. For the purposes of this study, erosion protection was assumed for culverts in alluvial soil streams and not for culverts in rock controlled streams. Bridge and culvert alternative designs were also developed to cause no adverse impact to existing 100-year floodplains in accordance with the County's "no adverse impact" floodplain management approach.

Alternative drainage structure types assumed for the alternative design analyses included corrugated metal arch pipe (CMP Arch Pipe), reinforced concrete box (RCB) culverts, and various types of bridge structures including pre-cast bridge units, cast-in-place concrete slab spans, prestressed slab beams, concrete slab and girder, and prestressed I-beam spans.

### 6.2.2 Open Channels

Open channel design pertains to roadside ditches as part of street drainage systems, off-street or off-site stormwater conveyance channels, and natural channels. The DCM states that channels should be designed for the 25 year storm with provisions for the 100 year storm within dedicated easements or right of way. Additional design requirements from the DCM are as follows:

- For Grass-Lined Channels and Waterways –
  - ***Velocity***. The maximum permissible velocity for the one hundred (100) year storm is six (6) feet per second and includes all transitions to or from channels and waterways with similar or different materials. In all cases, the velocity for the one hundred (100) year storm must be non-erosive. The minimum permissible velocity for the two (2) year storm is two (2) feet per second.
  - ***Slope.*** The flow line slope of the channel shall be a minimum of two (2) percent unless the velocity for the two (2) year storm flow is greater than two (2) feet per second, in which case the channel slope may be a minimum of one (1) percent. Compliance with this requirement must take into account the variation in channel flow due to distributed inflows to the channel. A reinforced concrete pilot channel must be used if the channel slope is less than one (1) percent. The pilot channel must be at least four (4) feet wide, two (2) inches deep, and be capable of withstanding vehicular loading. Any grass-lined portion of the channel bottom must have a slope of at least two (2) percent from that portion to the concrete-lined pilot channel. However, no open channel flow line slope may be less than one-half (0.5) percent.
  - ***Side Slopes.*** Side slopes shall be three (3) to one (1) or flatter.
  - ***Bottom Width.*** The minimum flat bottom width of the channel is three (3) feet.
  - ***Freeboard.*** All grass-lined channels shall be designed to convey the one hundred (100) year storm event. The freeboard for the channel shall be the velocity head for the one hundred (100) year storm.
- For Concrete-Lined Channels –
  - ***Velocity.*** In concrete-lined channels the probability of achieving supercritical flow is greatly increased. The designer must take care to insure against the

possibility of unanticipated hydraulic jumps forming in the channel in considering the 25 and 100 year storms. Flow with a Froude number equal to one (1) is unstable and should be avoided. If supercritical flow does occur, then freeboard and superelevation must be determined. In addition, all channels carrying supercritical flow shall be continuously lined with reinforced concrete.

– ***Freeboard.*** Adequate channel freeboard shall be provided for the 100 year storm in reaches flowing at critical depth by Equation 6-1 or using the energy grade line, whichever is less.

$$HFB = 2.0 + (0.025V)\left(d^{\frac{1}{3}}\right) \qquad \text{(Eq. 6-1)}$$

where,

HFB = Freeboard height (ft)
V = Velocity (fps)
d = Depth of flow (ft)

Freeboard shall be in addition to superelevation, standing waves and/or other water surface disturbances. Concrete sideslopes shall be extended to provide freeboard. Freeboard shall not be obtained by the construction of levees.

– ***Side Slopes.*** Since concrete lined channels do not require slope maintenance, the side slopes may be as steep as vertical with appropriate structural methods applied.

– ***Slope.*** The flow line slope of the channel shall be no less than one-half (0.5) percent and must also be sufficient to produce a velocity for the two (2) year storm flow of at least two (2) feet per second. Compliance with this requirement must take into account the variation in channel flow due to distributed inflows to the channel.

#### *6.2.3 Street Flow*

Streets and roadways serve an important and necessary drainage service even though their primary function is for the movement of traffic. The DCM states that the permissible flow of water in streets should be related to the extent and frequency of interference to traffic and the likelihood of flood damage to surrounding property for the 25 and 100 year frequency storms. Interference to traffic is regulated by design limits of the spread of water into traffic lanes. Flooding of surrounding property from streets is controlled by limiting curb buildup to the top of curb, [or by providing adequate conveyance in roadside ditches] for a 25 year storm which is designated as the design storm. Conveyance provisions for the 100 year storm must also be made within defined right of way and easements. (DCM, Section 3.1.0)

The minimum roadway clear widths for the 25-year storm for a given street classification are given in Table 3-1 of the DCM, as shown below. When the minimum clear width shown in the table is encroached by the spread of flow from the design storm, a separate storm drainage system or additional storm drainage capacity should be provided.

***Minimum Clear Widths for Roadway Design Due to Gutter Flow (DCM,Table 3-1)***

| ***Roadway Type*** | ***Proposed Usage*** | ***Minimum Clear Width (Feet)*** |
|---|---|---|
| 1. Local Street | a. General<br>b. Loop<br>c. Elbow | 0<br>0<br>0 |
| 2. Collector | a. Residential<br>b. Neighborhood<br>c. Commercial<br>d. Industrial<br>e. Primary,<br>4 Lanes<br>5 Lanes<br>4 Lanes Divided<br>6 Lanes Divided | 8<br>11<br>24<br>24<br><br>22<br>24<br>12 (each way)<br>12 (each way) |
| 3. Arterial | a. 4 Lanes, Undivided<br>b. 3 Lanes, One Way<br>c. 4 Lanes, One Way<br>d. 4 Lanes, with left turn lane<br>e. 4 Lanes Divided<br>f. 6 Lanes, Divided<br>g. 8 Lanes, Divided | 24<br>12<br>24<br>24<br>12 (each way)<br>12 (each way)<br>24 (each way) |
| Source: City of Austin, Department of Public Works and Transportation | | |

### *6.2.4 Storm Sewers*

Storm sewer systems are used to reduce street flow, enclose open channels, or to divert stormwater for minor watershed problem areas. The DCM states that storm drain systems are to be designed such that the 25-year hydraulic grade line shall remain six (6) inches below the theoretical gutter flow line of inlets. (DCM, Section 5.2.0) Additionally, storm sewers should have a minimum 25-year velocity of 2.5 feet per second to minimize deposition of solid material and a maximum 25-year velocity of 20 feet per second to prevent excessive erosion of the storm drain pipe material.

### 6.3 Capital Cost Estimates

Cost estimates were developed for recommended improvements at each of the problem areas identified in the study area. Component costs were estimated based on typical unit costs for construction applied to quantities of materials required for project implementation. Estimated capital costs for each project were based on costs for each component, plus 20 percent for construction contingencies and unlisted items. An additional 20 percent (for most cases) for engineering, legal, permitting, and surveying costs was also included. Costs for acquisition of private property or easements for project implementation are based on 2008 values obtained from the Travis Central Appraisal District (TCAD).

Unit costs for specific components of improvement projects were obtained from twelve month moving average low bid unit prices for statewide TxDOT projects. Unit cost adjustments were made to account for economy of scale where applicable. A summary of the unit costs generally applied is presented in Table 6-1.

***Table 6-1.***
***Summary of Estimated Unit Costs***

| ***Description***[1] | ***Unit*** | ***Unit Price ($/unit)*** |
|---|---|---|
| MOBILIZATION (5%) | LS | |
| BARRICADES/SIGNS/TRAFFIC HANDLING | Month | $4,000.00 |
| EROSION CONTROL | SY | $3.00 |
| TRENCH EXCAVATION PROTECTION | LF | $5.00 |
| CUT & RESTORING PAV (ASPH) | SY | $200.00 |
| REMOV PAV | SY | $6.00 |
| D-GR HMA(METH) TY-C PG70-22 | TON | $80.00 |
| D-GR HMA(METH) TY-A PG70-22 | TON | $85.00 |
| FL BS (CMP IN PLC)(TY A GR 4)(FNAL POS | CY | $35.00 |
| REMOV STR (PIPE) | LF | $15.00 |
| REMOV STR (BOX) | LF | $60.00 |
| EMBANKMENT (FINAL)(ORD COMP) | CY | $15.00 |
| EXCAVATION (ROADWAY AND CHANNEL) | CY | $25.00 |
| RC PIPE (CL III) (18 IN) | LF | $50.00 |

**Table 6-1.**
**Summary of Estimated Unit Costs (Continued)**

| Description[1] | Unit | Unit Price ($/unit) |
|---|---|---|
| RC PIPE (CL III) (24 IN) | LF | $60.00 |
| RC PIPE (CL III) (30 IN) | LF | $80.00 |
| RC PIPE (CL III) (36 IN) | LF | $90.00 |
| RC PIPE (CL III) (48 IN) | LF | $150.00 |
| 4-SIDED AREA INLET (4 FT X 4 FT) | EA | $6,000.00 |
| CURB INLET (10') (COA TYPE 1) | EA | $6,000.00 |
| STD PRE-CAST MH, (4' DIA) (COA) | EA | $3,500.00 |
| STD PRE-CAST MH, (5' DIA) (COA) | EA | $4,000.00 |
| CL B CONC (CHANNEL) | CY | $500.00 |
| CMP (GAL STL 48 IN) | LF | $125.00 |
| CMP (GAL STL 54 IN) | LF | $150.00 |
| CMP AR (GAL STL DES 2) | LF | $50.00 |
| CMP AR (GAL STL DES 3) | LF | $60.00 |
| CMP AR (GAL STL DES 4) | LF | $74.00 |
| CMP AR (GAL STL DES 5) | LF | $86.00 |
| CMP AR (GAL STL DES 6) | LF | $120.00 |
| CMP AR (GAL STL DES 7) | LF | $150.00 |
| CMP AR (GAL STL DES 9) | LF | $280.00 |
| CMP AR (GAL STL DES 12) | LF | $325.00 |
| CONC BOX CULV (6 FT X 3 FT) | LF | $340.00 |
| CONC BOX CULV (7 FT X 2 FT) | LF | $320.00 |
| CONC BOX CULV (7FT X 5 FT) | LF | $440.00 |
| CONC BOX CULV (8 FT X 3 FT) | LF | $350.00 |
| CONC BOX CULV (8 FT X 8 FT) | LF | $860.00 |
| CONC BOX CULV (10 FT X 5 FT) | LF | $425.00 |
| CONC BOX CULV (10 FT X 6 FT) | LF | $340.00 |
| CONC BOX CULV (10 FT X 10 FT) | LF | $880.00 |
| CONC BOX CULV (12 FT X 4 FT) | LF | $730.00 |
| CONC BOX CULV (12 FT X 5 FT) | LF | $830.00 |
| CONC BOX CULV (12 FT X 6 FT) | LF | $930.00 |
| SET (TY II)(48 IN)(CMP)(3:1)(C) | EA | $2,300.00 |
| SET (TY II)(54 IN)(CMP)(3:1)(C) | EA | $2,600.00 |
| SET (TY II)(DES 2)(CMP)(3:1)(C) | EA | $800.00 |
| SET (TY II)(DES 3)(CMP)(3:1)(C) | EA | $1,000.00 |
| SET (TY II)(DES 4)(CMP)(3:1)(C) | EA | $1,250.00 |
| SET (TY II)(DES 5)(CMP)(3:1)(C) | EA | $1,400.00 |

***Table 6-1.***
***Summary of Estimated Unit Costs (Concluded)***

| ***Description[1]*** | ***Unit*** | ***Unit Price ($/unit)*** |
|---|---|---|
| SET (TY II)(DES 6)(CMP)(3:1)(C) | EA | $2,200.00 |
| SET (TY II)(DES 7)(CMP)(3:1)(C) | EA | $1,800.00 |
| SET (TY II)(DES 9)(CMP)(3:1)(C) | EA | $3,500.00 |
| SET (TY II)(DES 11)(CMP)(3:1)(C) | EA | $3,800.00 |
| SET (TY II)(DES 12)(CMP)(3:1)(C) | EA | $4,000.00 |
| WINGWALL (FW-S)(HW=2 FT) | EA | $2,600.00 |
| WINGWALL (FW - 0) (HW=3 FT) | EA | $3,000.00 |
| WINGWALL (FW - 0) (HW=4 FT) | EA | $4,000.00 |
| WINGWALL (FW - 0) (HW=5 FT) | EA | $5,000.00 |
| WINGWALL (FW-S)(HW=6 FT) | EA | $4,200.00 |
| WINGWALL (FW-S)(HW=8 FT) | EA | $9,125.00 |
| WINGWALL (FW-S)(HW=10 FT) | EA | $15,000.00 |
| CROWN SPAN STR (UP TO 30-FT) | SF | $65.00 |
| CROWN SPAN STR (30-FT to 40-FT) | SF | $75.00 |
| BRIDGE STR (SLAB BEAM) | SF | $95.00 |
| BRIDGE STR (I BEAM) | SF | $65.00 |

[1]Reference TxDOT Standard Specification, 2004.

# Section 7
# Recommendations

Recommendations for flood mitigation in Travis County include both structural and non-structural solutions. For each problem area, a recommended plan meeting full design criteria was developed as described in Section 6.2, as well as a recommended plan that meets a minimum 2-year design standard. The recommended improvement plans and estimated capital costs for the top priority problem areas are presented in Volume 2 of this study report. Most of the recommended improvement plans presented for each problem area involve structural solutions, such as bridge and culvert improvements, channel improvements, and storm sewer systems. Non-structural solutions include acquisition of damageable properties within flood prone areas.

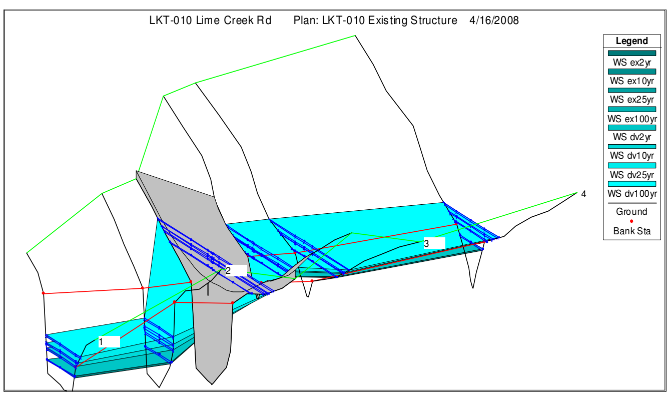
## 7.1 Non-Structural Recommendations

A number of properties were identified that presently exist in flood prone areas that are required to be removed for implementation of various structural improvements or are recommended to be removed in lieu of much more significant channel modifications, such as those properties within the Swiss Alpine Village Subdivision. Acquisition of these properties is recommended in order to reduce future flood damages and to secure the property necessary for future project implementation. Implementation of these future projects will result in flood damage reduction for a number of residential structures in the area.

For several problem areas, access to residential areas becomes entirely cut off during flooding conditions. In some of these areas, the value of property that becomes cut off is comparable to the cost of structural improvements required for mitigation. Two of these problem areas include the low-water crossings of Juniper Trail and Cottonwood Drive at Long Hollow. Acquisition of the properties cut off from access due to flooding at these two low-water crossings could be an option for the County to pursue in lieu of structural alternatives. This option is noted on the proposed alternative plans in Volume 2 and an estimate of capital costs for property acquisitions is included.

The County's existing ordinances related to drainage and floodplain management were reviewed as part of this study. The ordinances and proposed revisions thereto were found to provide high standards for development both within regulatory floodplains and outside of regulatory floodplains within the unincorporated areas of Travis County. The existing ordinances include standards for street drainage and storm sewer design, channel design, bridge and culvert design, and stormwater management facilities including detention basins. Ordinances are also in place for managing development within regulatory floodplains for consistent application across the County.

Hydraulic models were developed for high priority stream crossings and major channels within or adjacent to high priority subdivision problem areas in the study. These models provide detailed hydraulic information for small stream segments at problem areas that have not been studied in detail by FEMA and are presently not mapped. The hydraulic models provide the County with detailed information on flood levels that were not available before that can be used in the planning and regulation of future development. The new flood level data and enforcement of the existing ordinances will help ensure that future developed areas do not experience drainage and flood related problems or worsen downstream flood problem areas. The County should consider using the hydraulic model data for future floodplain studies as needed for FEMA map revisions, especially for Maha Creek near Jacobson Road and Swiss Alpine Village Subdivision where significant flood problems were identified.




### 7.2 Structural Recommendations

The majority of the recommended improvement plans for the top priority flood problem areas involve culvert and bridge improvements at stream crossings as presented in Volume 2. The recommended culverts and bridges were sized based on computed discharges and design criteria described in Section 4. The types of culvert and bridge upgrades were selected to meet

the capabilities and resources of Travis County maintenance crews wherever possible. Corrugated metal pipe arch were selected as a first option on smaller crossings, with reinforced box culverts and pre-cast bridge units being the next options. Larger crossings required bridge structures to meet minimum and full design criteria. Standard TxDOT bridge types were assumed for all bridge alternatives. The larger crossings also involve raising the existing road profile and, therefore, reconstruction of the approach roadway segments where large culverts or bridge structures are proposed.

Channel and storm sewer improvements, in addition to culvert improvements, are recommended for the top priority subdivision problem areas. Open channel improvements include enlarging, regrading, and/or lining large conveyance channels or tributaries running through some of the developed areas, but most of the channel improvements involve enlarging or installing new roadside ditch systems to properly drain flood prone areas. Where open ditches were not possible due to physical constraints or lack of grade, storm sewers were proposed. Storm sewers were also recommended to divert runoff around flood prone areas in some instances. Many of the proposed storm sewer and channel improvements also require the acquisition of permanent drainage easements to comply with current Travis County drainage requirements.

### *7.3 Estimated Capital Costs*

Tables 7-1 and 7-2 provide summaries of the estimated capital costs for recommended flood mitigation measures for each of the top priority problem areas. Estimated capital costs are provided for plans to meet the County's full design criteria as well as a design that provides significant drainage improvement, although less than the design criteria. The total capital cost estimate to meet the County's full design criteria totals over $48,000,000 while the capital cost to provide drainage improvements, less than the full design criteria, is almost $22,000,000. Detailed cost estimates of recommended plans for each top priority problem area are provided in Volume 2.

***Table 7-1.***
***Summary of Estimated Capital Costs for Stream Crossings***

| *Final Rank* | *Problem Area* | *Crossing ID* | *Alternative 1-Minimum Design Capital Cost* | *Alternative 2-Full Design Criteria Capital Cost* |
|---|---|---|---|---|
| 1 | Big Sandy Dr @ Long Hollow Creek | LKT-005 | $319,150 | $711,274 |
| 2 | Springdale Road @ Walnut Creek | WLN-001 | $3,246,061 | $3,580,756 |
| 3 | Juniper Trail @ Long Hollow | LKT-004 | $416,672 | $1,186,676 |
| 4 | Wyldwood Road @ Slaughter Creek | SLA-004 | $549,105 | $1,528,560 |
| 5 | Great Divide Road @ Little Barton Creek | LBA-001 | $331,004 | $1,391,004 |
| 6 | Fall Creek Road @ Fall Creek | FAL-001 | $213,322 | $858,434 |
| 7 | Pedernales Canyon Trail @ Lick Creek | LCK-001 | $433,516 | $526,096 |
| 8 | Slaughter Creek Drive @ Trib 1 to Slaughter Creek | SLA-005 | $330,664 | $763,927 |
| 9 | Tumbleweed Trail @ unnamed trib to Lake Austin | LKA-001 | $59,999 | $154,205 |
| 10 | Crystal Bend Drive @ Harris Branch | HRS-001 | $274,730 | $1,381,232 |
| 11 | Cottonwood Drive @ Long Hollow | LKT-003 | $224,372 | $867,244 |
| 12 | Jacobson Road @ Maha Creek | MAH-008 | $201,247 | $458,937 |
| 13 | Linden Road @ Maha Creek | MAH-009 | $404,168 | $3,576,385 |
| 14 | Live Oak Drive @ Sheep Hollow | LKT-002 | $168,329 | $339,730 |
| 15 | Springdale Road @ Trib 5 to Walnut Creek | WLN-002 | $183,741 | $270,946 |
| 16 | Gregg Lane @ Wilbarger Creek | WLB-004 | $278,039 | $1,371,626 |
| 17 | Jesse Bohls Rd. @ unnamed trib to Wilbarger Creek | WLB-002 | $279,310 | $2,189,503 |
| 18 | Lime Creek Road @ Fisher Hollow | LKT-010 | $165,130 | $557,420 |
| 19 | Nameless Road @ unnamed trib to Big Sandy | LKT-001 | $284,248 | $918,510 |
| 20 | D Morgan Road @ Trib to Grape Creek | BAR-002 | $96,854 | $683,118 |
| 21 | Bee Creek Road @ Bee Creek | WBC-001 | $379,595 | $924,162 |
| 22 | Navarro Creek Rd @ Navarro Creek | DRE-006 | $211,053 | $1,343,902 |
| 23 | Bitting School Road @ unnamed trib to Wilbarger Creek | WLB-012 | $655,131 | $5,276,098 |
| 24 | Weir Loop Circle @ Devil's Pen Creek | SLA-006 | $124,305 | $261,901 |
| 25 | Tom Sassman Road @ Maha Creek | MAH-003 | $1,123,764 | $1,726,228 |
| 26 | Felder Lane @ Cottonwood Creek | CTW-003 | $209,810 | $949,937 |
| 27 | Parsons Road @ Wilbarger Creek | WLB-009 | $437,766 | $1,584,547 |
| 28 | Westlake Drive @ unnamed trib to Lake Austin | WDT-001 | $46,452 | $131,656 |
| 29 | Nameless Road @ Nameless Hollow | LKT-007 | $220,924 | $1,257,092 |
| 30 | Ledgestone Terrace @ unnamed trib to Pen Creek | SLA-007 | $125,457 | $125,457 |
| 31 | Wild Basin Street @ unnamed trib to Bee Creek | BEE-001 | $81,451 | $146,876 |
| 32 | Caldwell Ln @ River Timber Dr | COL-001 | $69,644 | $69,644 |
| 33 | Nameless Road @ unnamed trib to Big Sandy | LKT-006 | $181,569 | $400,979 |
| 34 | Weir Loop @ Williamson Creek | WMS-001 | $47,209 | $58,075 |
| | | **Grand Total** | **$11,989,240** | **$36,815,718** |

**Table 7-2.**
**Summary of Estimated Capital Costs for Subdivision Areas**

| Final Rank | Problem Area | Alternative 1 Capital Cost | Alternative 2 Capital Cost |
|---|---|---|---|
| 1 | Swiss Alpine Subdivision | $947,835.16 | $2,069,741.75 |
| 2 | Arroyo Doble Subdivision | $1,049,473.00 | $1,243,873.00 |
| 3 | Twin Creeks Park Subdivision | $344,550.00 | $538,242.00 |
| 4 | Thoroughbred Farms Subdivision | $700,663.82 | $997,334.86 |
| 5 | Southwest Territory Subdivision | $916,439.83 | $1,071,206.64 |
| 6 | Austin Lake Estates Subdivision | $2,353,985.38 | $2,997,881.68 |
| | Subtotal Structural Improvements | $6,312,947 | $8,918,280 |
| | | | |
| | Swiss Alpine Subdivision Acquisitions | $3,740,915 | $3,902,147 |
| | **Grand Total** | **$10,053,862** | **$12,820,427** |

# Section 8
# Implementation and Funding

## *8.1 Introduction*

The recommended improvements for the problem areas identified as priorities in this study total over $49,000,000 (Section 7) to meet the County's current drainage standards. Obviously, implementation of these improvements will occur over several years as funding allows. Plans for implementing the identified mitigation measures will need to be considered in terms of the priorities and needs of other County operations to determine an appropriate level of funding in any given year. Many of the mitigation measures identified in this study may be undertaken by the County's own resources, including the Transportation and Natural Resources Road and Bridge maintenance crews, as their normal operating budget would allow each year. Some of the larger structural projects will likely require an outside contractor to construct and funding may have to be derived from capital improvement bonds or other sources.

Improvements recommended by this study are not comprehensive for the entire county. Some areas of the County were not included in the study area and other areas have been studied previously or have ongoing studies to address specific flood problem areas. The results of this study along with the results of the other individual flood studies that the County has participated in will need to be considered by the County each year in determining its overall priorities for flood mitigation. Obviously, most of the mitigation measures identified will be beyond the ability of the County's annual operating budget for funding. Therefore, additional funding measures will be required for implementation.

## *8.2 Funding Alternatives*

Implementation of major drainage improvements by Travis County will require commitment of significant funds and resources. There are several options for funding drainage improvements, including use of local resources and acquiring funds from outside sources including state and federal agencies.

## *8.3 County Funding Alternatives*

Historically, counties in Texas have financed drainage improvements with tax proceeds and fees through their Annual Operating budget or through the issuance of Capital Improvement Bonds to fund specific projects. The County is limited by law to developing a one-year budget.

Therefore, the County does not maintain a multi-year capital improvement plan or program. As needed, generally every four to five years, the County Commissioners call for capital improvement proposals from the County's departments, such as the construction of park facilities and major road improvements. Citizen Bond Advisory Committees are created, the departments develop detailed proposals, public hearings are held to discuss the needed work, and bond elections are held.[1]

### 8.3.1 Tax-Based/General Revenue Funding

Typically, with this method of funding, drainage activities and improvements are one of many "line items" in a County's Operating Budget that are supported with the combined pool of general revenues from ad valorem taxes, transportation fees, and other revenue. Capital financing is typically accomplished through cash transfers for small projects and general obligation bonds for major improvements. Operational activities are typically funded with general revenues. The County's Road and Bridge Division has an annual operating budget assigned each year and performs maintenance and constructs improvement projects identified for that year. Each year, the Road and Bridge Division will undertake specific drainage improvement projects utilizing County staff and equipment resources to perform the work.

### 8.3.2 Capital Improvement Bonds

Public agencies borrow funds in the financial markets through the issuance of bonds, then use the proceeds to construct public works project such as drainage improvements. The bond holders are repaid with interest, using revenues and/or fees collected from taxes levied on property or from a combination of revenues, fees, and taxes. In cases where public entities issue bonds, the bonds are classified as "tax exempt." On tax exempt bonds, the interest paid to bond holders is not classified as ordinary income; therefore, the bond holder does not have to pay income tax on the earnings from these investments. As a result, individuals and other investors are willing to lend their capital to governmental entities at lower interest rates than would be the case if the interest on these loans (bonds) were taxed by the federal government. Travis County has utilized this method periodically in the past to fund major infrastructure improvements and other needs. Most recently, the County votes authorized bonds to be issued in 2005 to fund a

[1] Hazard Mitigation Plan, Travis County, Texas, June 2003.

variety of improvements including roadway and bridge upgrades and the purchase of flood prone properties in specific areas that were identified in previous studies.

### 8.3.3 Municipal Funding Participation

Projects identified as part of the plan that offer a direct benefit to a local municipality will likely be candidates for joint funding by the County and local municipality. As an example, Great Divide Road was identified as a priority project as it is the single point of access across Little Barton Creek to a large residential area. The County only has jurisdiction of a small part of the roadway where the bridge crossing exists. The City of Bee Cave has jurisdiction for the roadway approaches on each side of the existing structure and most of Great Divide Road where the residences exist. Most of the roadway is within the City of Bee Cave. Therefore, it is likely that a joint funding agreement will be needed between the County and City of Bee Cave before this project would move forward. In addition, the County may elect to identify other potential projects that would have a direct benefit to other municipalities to develop partnerships for funding improvements.

## 8.4 State and Federal Participation

State and federal funding may be available for some of the recommended improvement projects. State and federal funding may be derived from several sources including the following:

- Low interest loans for flood control projects from the Texas Water Development Board;
- Participation in the federal Off System Bridge Program that is administered by the Texas Department of Transportation (TXDOT) to upgrade of specific bridge class drainage structures identified by TXDOT;
- Matching grants from the Federal Emergency Management Agency (FEMA) Flood Mitigation Assistance (FMA) Program; and
- Local Flood Damage Reduction Program of the U.S. Army Corps of Engineers as authorized in Section 205 of the 1948 Flood Control Act.

Utilization of state, federal, and other funding will be important in order for the County to implement larger flood protection projects previously identified by the U.S. Army Corps of Engineers studies undertaken for the Colorado River, Onion Creek, and Walnut Creek watersheds. These projects largely include non-structural solutions where structures are purchased and removed from the floodplain. Acquisition of state and federal funding will require planning and coordination with each of the agencies to ensure that funds are available and projects are completed in a timely manner. An overview of various state and federal funding options is presented in the following sections.

### 8.4.1 Texas Water Development Board Loan Assistance

Loans are available from the Texas Water Development Board for the planning, design, and construction of flood control projects. The Texas Water Development Fund is used to provide loans to eligible applicants for construction of flood control projects. The Texas Water Development Fund consists of several accounts including the Flood Control Account. The Flood Control Account provides financing for structural and non-structural flood protection improvements such as construction of stormwater retention basins; enlargement of stream channels; modification or reconstruction of bridges; acquisition of floodplain land for use as public open space, acquisition and removal of buildings located in a floodplain, relocation of residents of buildings removed from a floodplain, public beach renourishment, flood warning systems; control of coastal erosion; and development of floodplain management plans. The interest rate on a Texas Water Development Fund loan varies depending on the cost of TWDB funds. The lending rate scales are set at 0.35 percent above the TWDB's borrowing cost. The lending rates are intended to provide reasonable rates to its customers while covering the TWDB's cost of funds and risk exposure. Repayment periods for loans from the Texas Water Development Fund generally range from 20 to 25 years.

### 8.4.2 Texas Department of Transportation

Many of the recommended projects involve replacement of low water crossings where dangerous overtopping conditions are frequent and the potential for loss of life exists. Many of the low water crossings are single access ways to residential areas which are a high priority for the County to mitigate. The federal off-system bridge program is administered by the Texas Department of Transportation (TxDOT) to replace or rehabilitate structurally deficient and functionally obsolete bridges on public roads and streets off the designated State highway system. The usual fund participation for an off system bridge project is 80% federal, 10% state, and 10% local. For any crossing that may be eligible for funding under the off system bridge program, the County would be responsible for 10% of the total cost. However, Texas Administrative Code Title 43, Section 15.55(d) provides under certain conditions, the 10% Local Government match fund participation requirement may be waived by agreement of the Local

Government to perform an equivalent dollar amount of structural work on other deficient bridges ("equivalent match project"). Travis County, in this case, performs a number of bridge and culvert improvement projects that would likely serve as the "equivalent match project" to serve as the Local Government share. The Austin District of TxDOT is responsible for coordinating the local off system bridge program in Travis County. The County should coordinate with TxDOT on the priorities for off system bridge replacements as this program would help offset significant costs for the County.

### *8.4.3 FEMA Flood Mitigation Assistance Program*

The Flood Mitigation Assistance (FMA) Program is a federal grant program administered by the Texas Water Development Board (TWDB), under an Agreement with the Federal Emergency Management Agency (FEMA). This program provides federal funding to assist States and communities in implementing measures to reduce or eliminate the long-term risk of flood damage to buildings, manufactured homes, and other structures insurable under the National Flood Insurance Program (NFIP). The FMA program was created as part of the National Flood Insurance Reform Act of 1994 (42 U.S.C. 4101) with the goal of reducing or eliminating claims under the NFIP. The FMA is a pre-disaster grant program.

The FMA Program may provide grant funds for no more than 75 percent of the total cost of the following types of projects:

- Acquisition of insured structures and real property and easements restricting property use;
- Relocation of insured structures;
- Demolition and removal of insured structures;
- Elevation of insured structures;
- Other activities to bring insured structures into flood plain management compliance;
- Minor physical flood mitigation projects; and
- Beach nourishment activities.

A community is available for project grants if it is not on probation or suspended under the NFIP, and if it has received FEMA approval of its flood mitigation plan. The FMA Program requires a 25 percent local cost share of which not more than one-half may be in-kind services. Application for project grant funds are received by the TWDB each year and are evaluated based on the following criteria:

- The extent the project reduces future NFIP claims;
- Projects with the highest benefit/cost ratio;
- Projects which benefit the greatest number of NFIP-insured structures;
- The extent the project results in a long-term flooding solution and requires minimum maintenance;
- Whether the project affects structures in an identified floodway or flood plain;
- The extent to which the sponsor is providing greater than the required 25 percent cost share;
- Whether the applicant or community participates in the Community Rating System; and
- The multi-objective nature of the project.

The applications are evaluated by the TWDB and recommendations for grant award are forwarded to FEMA. FEMA currently restricts the amount of funds available. No community can receive more than $3,300,000 per five-year period. Due to the limited funds available for projects each year, the TWDB evaluates the applications and prioritizes for FEMA only those applications that meet the federal requirements. Acquisition of funds from the FMA Program is competitive and, in recent years, the amount of funding available to the state has been on the order of $1,000,000 for all communities. Projects involving acquisition of insured or insurable structures are generally ranked higher than other types of requests. Applications for funding are accepted year round, however, the evaluation of all applications for the next fiscal year are typically performed in August or September of each year. The Texas Water Development Board of Directors receives and approves the rankings to be forwarded to FEMA. The recommended projects are funded by FEMA based on the amount of funds made available to the state. Funds are typically disbursed the following January.

The County has participated in previous studies that have identified the acquisition of flood prone structures as the recommended plan for flood mitigation in those specific areas (i.e. Graveyard Point, Timber Creek, Thoroughbred Farms, Arroyo Doble). The County will likely pursue funding for a number of areas that have been identified in previous studies as floodplain acquisition through the FEMA Flood Mitigation Assistance Program. With a 75% federal participation, the County would be able to stretch available funds to purchase more flood prone properties.

### *8.4.4 U.S. Army Corps of Engineers Local Flood Damage Reduction Program*

In addition to projects that receive specific authorization from Congress, Section 205 of the 1948 Flood Control Act, as amended, provides authority for the U.S. Army Corps of Engineers (USACE) to plan and construct small flood damage reduction projects. A project is accepted for funding only after detailed investigation clearly shows its engineering feasibility, environmental acceptability, and economic justification. Each project must be complete within itself, not part of a larger project. The maximum federal participation is $7,000,000, which includes both planning and construction costs. Costs of lands, easements, and operation and maintenance must be non-federal.

The Section 205 program can fund both structural and nonstructural projects. Structural projects may include levees, flood walls, channel enlargements, diversion channels, and bridge modifications. Nonstructural projects, which will have little or no effect on flood levels, may include measures such as floodplain acquisition, floodproofing, relocation of structures, and flood warning systems. After a local agency, such as the County, requests a potential project, the Corps will conduct a feasibility study if it appears the problem may have a federal interest and if funds are available. The feasibility study begins at federal expense up to $100,000. Study costs in excess of $100,000 are shared 50/50 with the local agency. In the feasibility study, the problem is defined, the federal interest is determined, potential solutions are identified, and the most feasible plan is chosen. The costs, benefits, and environmental impacts of the potential project are analyzed. No more than 3 years should pass between the start of the feasibility study and the time the project is ready for construction.

Costs for Section 205 flood damage reduction projects are shared between the federal government and local agency in accordance with the Water Resources Development Act of 1986, as amended. During construction, the local agency must contribute 35 percent of the total cost of a project, with credit granted toward this amount for providing lands, easements, and right-of-way, and pay a minimum cash requirement of 5 percent of the total project cost. Local contributions in excess of 50 percent of the total project cost are reimbursed by the Federal Government. The Fort Worth District of the U.S. Army Corps of Engineers would be responsible for coordinating any Local Flood Damage Reduction Projects for the Travis County area.